Popular Astronomy.

Vol. XIX, No. 8. OCTOBER, 1911. Whole No., 188

THE CONTRIBUTION OF ASTRONOMY TO GENERAL CULTURE.*

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The word culture may be interpreted in such widely different ways, according to the points of view of different individuals, that its definition might properly be thought to be essential before I proceed with my remarks. I shall forego any such preliminary, however, and hope to use the term in so broad a way that it may include what any one might mean by its use—learning, knowledge, or the enduring acquaintance with well-thought ideas.

I shall also refer to some of the influences of the study of this ancient branch of learning upon both the teacher and the taught, and the enlargement of mental horizons which its pursuit brings to those who may give much or little of their time to it.

It may be well to approach the matter in a somewhat historical manner, although progress here, as elsewhere has not been steady, but intermittent, as the genius of some man has illumined here and there the pathway of knowledge. Had one the time for the necessary historical investigation, I believe it would not be difficult to trace the development of this or other branches of learning in such away that the lives of students should overlap, in point of time, back to the earliest beginnings of recorded history. Thus we could picture the accretions of knowledge, and often of error, as handed on from one worker to another, of very different ability, in very different and perhaps distant lands, and with very unequal value in

* Abridged from an address delivered at the dedication of the Swasey Observatory, Denison University, June 15, 1910.

their separate contributions. Thus the astronomical progress of more than four centuries might be represented in the linkage of the lives of eight men, as follows:

	DIED		DIED
Copernicus	1543	Newton	1727
Apianus	1552	Halley	1742
Tycho	1601	W. Herschel	1822
Galileo	1642	F.G.W. Struve	1864

It remains to me a singular fact that astronomy should have been one of the oldest of the sciences, even in superstitious ages. We should naturally think in the first place of agriculture, meteorology, anatomy and medicine, for instance, as subjects much nearer at hand than star-lore. I am inclined to think that the Chaldean shepherds have been overworked, that their contemplation of the nocturnal skies may have been a secondary rather than a primary concern with them. Is it not possible that we owe as much to the hardy venturers upon uncharted seas, whose course could be set only by the sun and stars when familiar landmarks of the coast had disappeared from view?

But, whatever the cause, the fact remains that the early philosophy concerned itself with astronomy to a degree which, even an astronomer may admit, was disproportionate to the benefits it was conferring upon humanity. Thales, among the earliest of the Greek philosophers, was seeking for fundamentals and speculating on causes. Both the unchangeable character of the starry skies, and, contrariwise, the variations in them, caused by time and seasons, stimulated speculation. Pythagoras perhaps anticipated by centuries the later knowledge of the rotation and revolution of the earth. With a singular detachment of mind from the immediately practical problems, the ultimate origins and causes were sought. Thus the culture of those ages was deeply impressed by astronomy, as interpreted by the philosophers of each period. With the advent of Hipparchus, the greatest astronomer of antiquity, in the second century before Christ, there was introduced the sound principle of basing the science upon observations, rather than upon general ideas of a speculative nature. How hard his successors have found it to follow in that simple but severe test of theory by fact!

* * *

With the advent of Copernicus, (1473-1543), what an immense expansion of mind was prepared for the intellectual

world by the substitution of the true heliocentric system for the complicated makeshifts of Ptolemy! Not until after his death did his views receive much attention, but the opposition they aroused in clerical quarters doubtless greatly helped to diffuse them. And now came the great explorations of Columbus and his fellow pioneers on trackless oceans. Indeed, astronomy had largely contributed to the general culture of the times, to the grand awakening, the renaissance. Evidence was accumulating to show that comparatively simple laws were governing the complex motions of planets. The careful observations by Tycho and the great generalizations of Kepler were in the logical order of the day. Consider the expansion of ideas, the increase of general culture, which followed the discoveries made by Galileo, as soon as he pointed his perfected telescope toward the moon, the sun, and planets; the existence on the moon of mountains and topography of the general sort of that of the earth; the spots on the ecclesiastically immaculate sun, its rotation on its axis in twenty-five days; the moons of Jupiter and their rapid revolution; the mysterious appendage of Saturn not at first discerned as a ring.

These discoveries, which were merely waiting for the optical power necessary for their revelation, profoundly affected the mental attitude of the intellectual people of the times, when the new knowledge had been diffused. A new place was given to the planets, in their relation to the earth, and a less exalted status in the solar system was the logical consequence for the earth. With its increased, but uncoördinated knowledge, science was awaiting its Newton; but it was almost reluctantly that he gave from his store of knowledge, and we must not forget the great credit due to Edmund Halley for persuading Newton to present the principles he had formulated to the Royal Society. Not only this, but Halley undertook the publication, finally at his own expense (when the coffers of the Royal Society were found to have been drained by other undertakings) of the immortal *Principia* of Newton.

The great impetus thus given to mathematical research, fostered in many cases by monarchs whose other contributions to the uplift of humanity were few, brought brilliant results, and gave the means and methods which led to such a great generalization as that of LaPlace. We must not forget the earlier and independent philosophizing of Wright of Durham, and of Immanuel Kant of Königsburg. LaPlace, however, had the mathematical skill and genius to establish many

of his conclusions upon a rigid foundation of demonstration. But, in many respects, the generalization of the Nebular Hypothesis outreached observations and mathematical proof. His mind appears to have leaped over barriers which might soberly have been regarded as unsurmountable. He had probably himself hardly seen a spiral, or even a ring nebula. It was beyond the reach of the imagination that men would some day know the chemical constitution of the sun, still less that of the vastly more distant stars and nebulae. But of course the researches of Messier (Louis Fifteenth's "Ferret of Comets") and the splendid investigations of William Herschel, who in 1786 gave to the Royal Society his great catalogue of 1000 nebulae, were available to LaPlace.

Five years before the publication of the *Systeme du Monde*, which is dated 1796, Herschel, in 1791, had propounded the view that the nebula differed in nature from the stars. Upon this view he founded his theory of stellar evolution. It has a familiar sound to us now, quite in line with the expanding thought of the last half century. His development of the idea was apparently quite independent of the theory of LaPlace, which was published between successive papers of Herschel. He early registered his view that the self-luminous matter of the nebulæ was "more fit to produce a star by its condensation than to depend on the star for its existence." He arranged in an orderly series the different objects he had discovered and found "perhaps not so much difference as would be in an annual description of the human figure, were it given from the birth of a child till he comes to be a man in his prime." This reference to the evolution theory of Herschel is made here as a matter of justice; but he is far better known by his many observational discoveries than by his speculation, while La Place is doubtless better known for his Nebular Hypothesis than for his splendid work, the *Mecanique Celeste*.

The impress of the hypothesis of La Place upon the culture of the nineteenth century has been profound. What collegian has escaped the grandeur of the conception of so complicated a result as our solar system developing under comparatively simple laws? To have this conception brought distinctly to the attention of the student is, to my thinking, almost argument enough for making astronomy a required study in college.

Here let me answer in advance the question often asked of the practical astronomer or astrophysicist: Is the hypothesis of LaPlace now obsolete, and discarded, or supplanted by

views better in accord with modern research? My answer would be in the negative, and I know that this view is shared by many of my friends whose opinion I value. It is true that this theory of LaPlace is inadequate in some respects, and is mathematically unfounded in some particulars. Its premises need modification, and it also leaves much unexplained. But no adequate substitute has been proposed, and the increased study of the different phases of development, as inferred from stellar spectra, supports the LaPlacean theory surprisingly.

Let us pass to another of the great discoveries of the nineteenth century, crystallizing in the decade when *The Origin of Species* appeared. I refer the interpretation of celestial spectra. From the beginning of the century, the existence of dark lines in the solar spectrum had been known, and as early as 1817 Fraunhofer had examined with the prism the light from some of the stars and planets. The double dark line in the solar spectrum (known as D) was known to coincide closely with the bright line in the spectrum of the sodium flame. Stokes, Balfour, Stewart, Foucault, had all groped near to the truth. It was Kirchoff, whose researches were made in connection with the eminent chemist Robert Bunsen, who announced in a communication to the Berlin Academy of Sciences, in 1859, the correct interpretation of the dark lines in the spectrum of sun or star: they show the presence of an envelope of glowing vapors around the star.

Here again, a tremendous expansion was instantly given to the horizon of thinking people. But to astronomers it was undoubtedly a far more impressive discovery, for it was the key to open the door to indefinite new realms of knowledge. Hereafter the position of a heavenly body and its motions were not to be the sole objects of inquiry, but their physical and chemical nature were to be investigated. And one of the special features of the discovery was that the spectroscope suffered no limitations from distance: provided the light was bright enough for analysis, the most distant star could be as well investigated as the nearest. This is of immense advantage, for in practically all investigations which depend upon angular motion (across the face of the sky) the errors of a determination increase proportionately with the distance from the Earth.

* * *

This brings us to another of the great principles revealed by the continued celestial application of the spectroscope and

spectrograph, namely, that of the qualitative unity of the universe. Such ideas as this, when properly impressed in the literature of science, cannot fail to affect markedly our conception of the universe, and our relation to it, and thus to contribute to the world's culture. I cannot feel that the idea has ever been sufficiently emphasized in popular writings or teachings. In essence, it is this: Despite the immense quantitative range in the universe, from the infinitesimal to the almost infinitely large, in mass, in space, and in time; qualitatively the range is very narrow, and our sun, our earth, our very bodies, very fairly represent the whole range of quality in the universe. The chemical elements with which we are familiar, which form the basis of our experience on earth, or are spectroscopically obvious in the sun, are essentially the same in the most distant star.

In a universe whose spatial depths are not sounded even by thousands of millions of millions of miles, populated by millions, (perhaps thousands of millions) of vast objects, why should there not be thousands or millions of kinds of matter—chemical elements by the millions? I see no answer but the fact that there are not, so far as terrestrial or celestial chemistry can yet ascertain. In a century's progress in chemistry, the number of elements detected and differentiated is less than one hundred; and the outlook, as I, without any technical knowledge, understand it, is toward a decrease rather than an increase of the number of elements. And it is just those very elements with which we are most closely associated in our bodies and in our surroundings that particularly abound in the far reaches of space; hydrogen is present, less than half a dozen stars excepted, in every star and gaseous nebula in the heavens; oxygen, nitrogen, silicon, carbon, magnesium, sodium—the most familiar elements of our atmosphere and the earth's crust—are conspicuous in the spectra of stars, both early and late in the course of stellar evolution. Helium, so recently discovered in the earth, after being known to astronomers as present in the sun for the quarter of a century previously, also plays an especially important part in the chemistry of one of the most interesting types of stars, being the chief characteristic of the stars of the *Orion* type. There is one form of hydrogen which chemists have not yet produced in the laboratory, although the keen analysis of Professor E. C Pickering established its existence in a few special stars a decade ago. Nebulum, too, will pre-

sumably be found within the earth, perhaps occluded in some crystals yet to be found into which it may have been absorbed (like helium) ages ago.

This consideration of the homogeneity of the universe offers us some genuine consolation, when we have been depressed by reflections on the immensity of the universe and the utter insignificance of our earth, or our solar system. We may proudly remember that, nevertheless, in quality, which is perhaps a far more essential matter, we share in the choicest of the whole universe. It is a tempting speculation to infer that, if matter does not differ widely in quality in the universe, mind, too, in its relation to matter, is not subject to an extensive range. No logical person can believe that the conditions for the mutual existence of mind and matter solely exist on this particular planet of this particular star which we call the sun. Hence we could guess that the sentient beings on other spheres of space would not differ so utterly from ourselves. But such speculations can scarcely ever be subject to the test of experiment or observation, and may not be soberly pursued further.

* * *

The battleground of modern practical astronomy is shifting, out to the problem of the structure of the sidereal universe. The first Herschel attacked the problem, and by his observations laid a foundation for later work. The question of great interest now is, Whither? The genius of the eminent Dutch astronomer, Kapteyn, has detected law in the apparently random residual motions of the fixed stars. Dealing with stars, not singly but in great groups, he has found evidences of what he has called "star streaming." The study began with the determination of the sun's way, the path along which the sun is hurrying, carrying with him his unconscious planets, toward the region between the constellations Hercules and Lyra. Other astronomers confirm the conclusions of Kapteyn that there are in the sidereal universe at least two great streams of stars, and that they cross each other and mingle at some points. Such a problem is so vast, and the data required are so extensive, that it transcends the capacity of the astronomers of one country. Like many other large practical problems, as for instance the great star catalogue of the *Astronomische Gesellschaft*, or the great photographic chart and catalogue of the whole heavens, such undertakings have to be international. Conferences, charming in their generous hospitality and fraternal courtesy, are now being often held in different countries.

The international Solar Union, for the coöperative study of the sun, and its phenomena, met last year at Pasadena. Such gatherings, becoming frequent in many other branches of science and art, are quietly but powerfully contributing to the cause of international peace. Continued and developed, they will operate effectively against the crowning absurdity of our age, the huge armaments of the great powers. If the productive power of the men thus withdrawn from useful activity could be utilized, and the vast sums of money wasted on unnecessary ships could be spent on submerged humanity, how immense would be the gain to civilization!

In celebrating to-day the opening of the beautiful observatory which will hereafter develop in this institution the science which has been my theme, it is fitting that we should briefly consider the advantages to student and teacher of the study of astronomy, both general and practical. The eminent classical authority, Professor Mahaffy, once told me that at Trinity College, Dublin, there were but two required subjects in the curriculum: logic and astronomy; and he justified this choice. It is surely true that no other subject of college instruction so instantly or so greatly broadens the horizon of the pupil. It is likely to catch the imagination and interest as few other topics do, and particularly when an observatory is at hand, where celestial objects and their phenomena may be demonstrated to all the members of a class. The vision of the planet Saturn or of a fine star cluster, in a good telescope, is likely to produce an impression that time will hardly efface. As a foundation for geology, geography and meteorology, and as affording constant application of principles previously learned in mathematics, physics and chemistry, astronomy has a particularly important place in the college curriculum. Mere familiarity with the principal constellations, once acquired in connection with a course in astronomy, will always prove a pleasure to its possessors, perhaps increasingly so in later life. The understanding of the general facts of planetary motion, as of the changes from evening to morning star, is also likely to be a permanent source of satisfaction.

The pursuit of courses of practical astronomy in an observatory is essential to the education of an engineer, and very desirable for those specializing in the physical sciences. The art of determining the time and the observer's position on earth from observations of the stars, gives the student who acquires it a certain self-reliance that is of lasting value to him.

The accuracy necessary in all computations involved in the reduction of his observations gives an exceptionally good drill in applied mathematics. The principle that no observation made by the human eye is absolutely precise, and that no instrument is ever in perfect adjustment, and that these errors must be determined and allowed for—this principle is of obvious use in training of any student for precision in any future work.

Courses or studies in astrophysics, such as observing, measuring and following the motions and changes of sun-spots, examining with the spectroscope the fascinating solar prominences and eruptions, measuring the brightness of the stars, determining the changes in light of the variable stars—all these commonly prove of much interest to the pupil, and stimulate him to the closer observation of nature.

To the teacher, also, the observatory is no less important than to the student. Here he gets information at first hand, notes with his own eye phenomena he had only dimly understood from descriptions in text-books. His enthusiasm for his work is likely to be greatly increased by the opportunity to see for himself, and to show to his pupils the phenomena. With a well equipped observatory, the teacher can, if his time permits, also make real contributions to science, and no man can make such researches, modest though they may be, without gaining new enthusiasm for his work as teacher, and without imparting this interest to his pupils.

AN OPEN AIR TELESCOPE.*

DAVID TODD.

"Out upon the border-land I see the glimmer of new lights that wait for their interpretation, and the great telescopes of the future must be their interpreters."—*Alvan Graham Clark* (1893.)†

But enthusiast for the great telescope as Clark always was, the advance of astronomy during the fifteen years since his death has far outstripped even his sanguine expectation. Already we have a number of newly-discovered variable stars

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* Reprinted from the American Journal of Science—Fourth Series, Vol. XXXII, No. 187, July 1911.

† Clark, Astron. and Astrophys. xii, 678, 1893.

of the antalgol type, bright at intervals but most of the time very faint, and the minimum light of some of which goes far beyond the visual reach of present telescopes. Ritchey's marvelous photographs of nebula and star-clusters have brought to light unexpected features of these primal cloud-like forms, without minute optical knowledge of which we can scarcely hope ever to know their full significance in the cosmogony. These are but two of the "new lights" that await the present-day astronomer's interpretation.

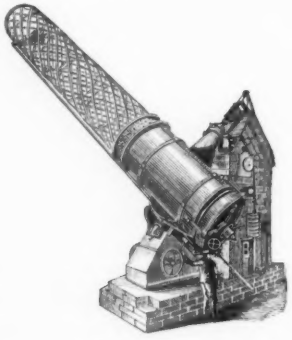


FIGURE 1.
4-foot Melbourne Reflector. (Designed and built by Thomas Grubb.)*

All telescopes are made up of three parts: Objectglass, eyepiece, and some form of rigid mechanical connection between the two. Usually this last is a round tube, either cylindrical or conical; but there is no optical reason why it may not take any shape that the exigencies of mechanics or engineering may demand.

Many open-tube telescopes have been built. Huygens (1629-95) even built one with no tube at all, an aerial telescope, as he called it; the objective in a counterbalanced cell with universal joint, mounted on top of a tall pole. He drew the axis of the objective into approximate line with the axis of the ocular by means of a small chord or wire reaching down to the observer on the ground. No objective of modern optical excellence could ever be satisfactorily used in this way. The 4-foot Melbourne reflector designed and built by Thomas Grubb (1800-78) has an open tube of spirally interlacing straps of steel. (Fig. 1.)

* Grubb, T., Phil. Trans. Roy. Soc. clix, 127, 1869.

The superior performance of a great telescope in the open air has long been known to astronomers. The huge instruments of Sir William Herschel (1738-1822) (Fig. 2), of Lord Rosse (1800-67) (Fig. 3), and of Lassell (1799-1880),* were all open-air instruments. All these were reflectors of course; but the same is true of refractors, as I found in 1907 when exigency required the mounting of the 18-inch Amherst refractor in the open-air tennis court of Oficina Alianza, in the foothills of the Andes above Iquique, Chile. With a serene atmosphere, cloudless, rainless and windless, it was not surprising that the Expedition brought back to Professor Lowell many thousand

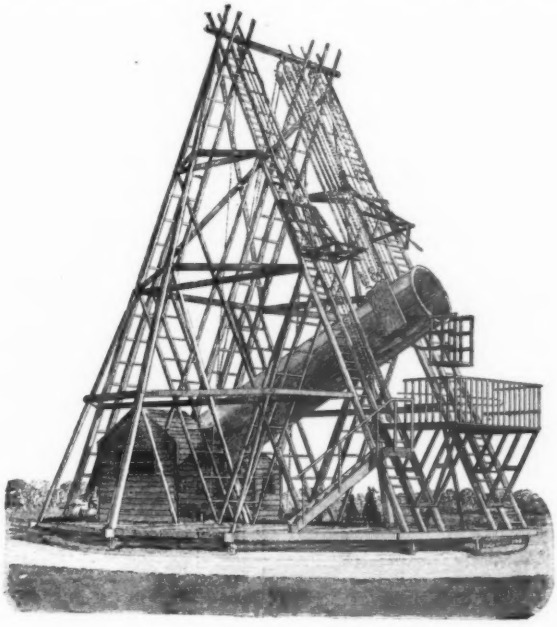


FIGURE 2.

Sir William Herschel's 40-foot Telescope. (Incribed to his Royal Patron, King George the Third, 1795.)†

photographs of Mars which far surpassed all contemporary pictures. The universal excellence of definition at Alianza was largely due to open-air working of the telescope; and no as-

* Lassell, Mem. Roy. Astron. Soc. xxxvi, 1867.

† Herschel, W., Phil. Trans. for 1795, p. 347.

tronomer who has once had such an experience would ever insist on operating a telescope from the interior of a dome, except as protection from the weather necessitated it.

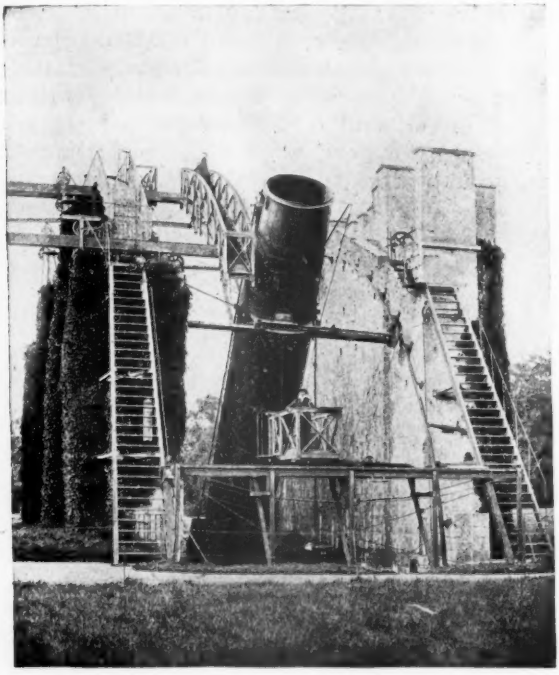


FIGURE 3.
Lord Rosse's Great six-foot Reflecting Telescope.
(Birr Castle, Parsonstown, Ireland.)*

The design for a type of open-air telescope which it is the object of this paper to present is the outcome of many years of practical work with both reflectors and refractors.

The optical advantages of great focal length were known to the earliest telescope makers, especially Huygens, Cassini (1625-1712), Hevelius (1611-87), and Bianchini (1662-1729), whose instruments had single-lens objectives, the harmful aberrations of which were, they found, very greatly reduced by figuring the lens nearly flat, so as to throw the focus remote

* Rosse, Phil. Trans. cli. 681, 1861.

from the objectglass. But these early makers of long telescopes were deprived of realizing the full optical advantage of this construction by the backward condition of: first, the art of making optical glass; second, the art of figuring and polishing a lens; third, the undeveloped stage of metal working; and fourth, the lack of suitable engineering design. (Fig. 4.)

To any practical astronomer, the almost insuperable difficulty in the use of such a telescope would immediately occur. Auzout (1630-91) perhaps built and used a similar one 600 feet in length, but I cannot see how he could ever have done either, with the lack of resources of his day.

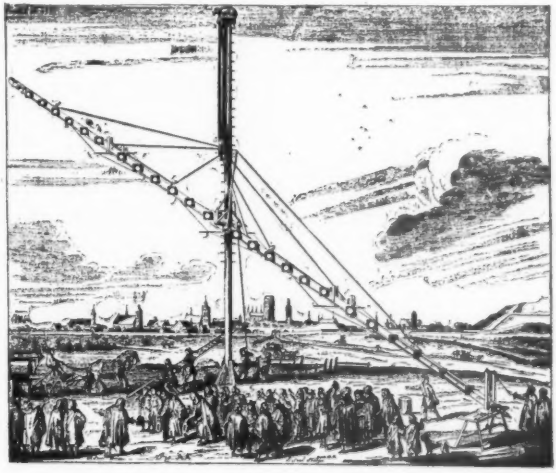


FIGURE 4.
Typical Great Telescope of the 17th Century.
(Built and used by Hevelius at Dantzig.)

The Hall-Dollond (1703-71)—(1706-61) invention of the achromatic objective did not cancel the desirability of great focal length, and subsequent investigators have not wholly eliminated it. With the longer radii of curvature of the surfaces, both crown and flint lenses can be reduced to a minimum in thickness with corresponding reduction of the loss of light by absorption. The chief gain of great focal length, as Hastings has shown,* is that both spherical and chromatic aberrations are more effectively reduced.

* Hastings. The Sid. Messenger, x, 335, 1891.

While the parts that make up the complete telescope are but three, the elements that interfere with, and even preclude, its perfect construction and working are essentially but three also. Foremost of all is the ever mobile atmosphere which, though it be transparent, is always quivering and tremulous, never quiescent; second, the imperfections of work of glassmaker and optician; and third, insufficient and imperfect design or malconstruction of mechanical parts of the telescope or mounting, which often interfere seriously with its working, or stand in the way of advance to greater optical power.

A century ago the 40-foot reflector of Sir William Herschel was in use at Slough, and six-inch object glasses were considered the largest possible. A half-century later Lord Rosse had finished his 6-foot reflector at Parsonstown, and the Clarks were beginning an 18½-inch objective,—a truly great advance.

The years since then have brought unparalleled progress in glass construction,* in optical methods, and even more in the mechanic arts. Telescope builders have advantaged greatly from all this practical progress, culminating in the 40-inch Yerkes telescope (1897), a noble instrument which has given excellent account of itself in the skilful hands of Barnard and Burnham, Frost, Hale, and Ritchey.† (Fig. 5.) But it is a close approach to the ultimate size attainable in the refracting telescope, so long as we confine ourselves to this type of mounting. The 40-inch glass, too, is in itself so weighty, in consequence of great thickness of both the lenses requisite to accommodate a relatively short tube, that actual flexure of the glass begins to appear as an obstacle to perfect optical performance at varying altitudes. And it is probable that larger objectives of this relatively short focal length would have to be figured for best performance only within a limited range in zenith distance. Needless to say, too, the protecting dome and the cumbrous rising-floor, when added to the cost of the instrument itself, practically prohibit much farther increase of size.‡

Solution of the problem of the long telescope, then, resolves itself into two general divisions: (1) to build the tube so that its flexure shall be negligible. The elder Herschel and Lord Rosse both succeeded in this; but their tubes, although the largest ever built, were relatively short. (2) to mount the

* Vogel. Astrophys. Jour. v, 75, 1807.

† Hale, Astrophys. Jour. vi, 37, 1897.

‡ All the previous illustrations are taken from my *Stars and Telescopes*, by courtesy of the publishers, Messrs. Little, Brown & Company, Boston.

weighty tube so that it can be pointed with ease to any part of the sky. The mechanical genius of Herschel selected the only feasible type of mounting for a structure of such great weight; and with certain modifications embodying the engineering and mechanical practice of the present day, his design must remain forever the basis of that type of mounting, which, all told, is

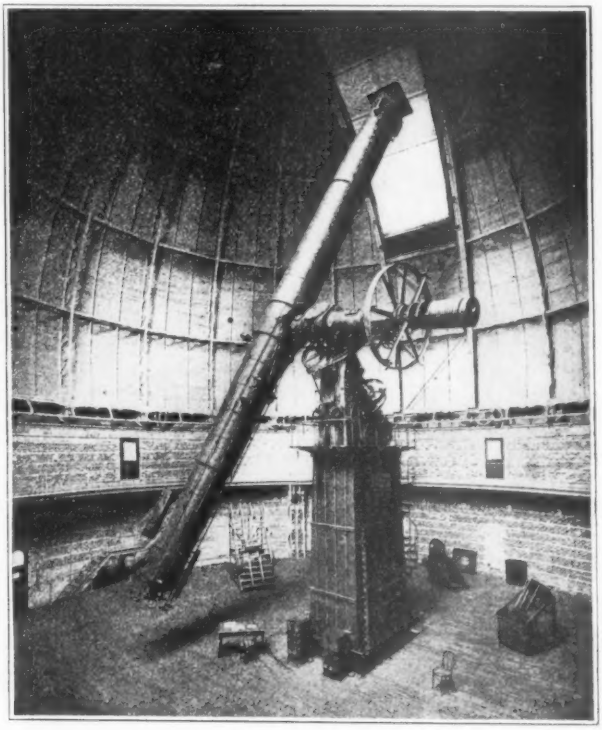


FIGURE 5.

40-inch Telescope of the Yerkes Observatory. (Glass by Mantois, objective by Alvan Clark & Sons, of Cambridgeport, mounting by Warner & Swasey, of Cleveland. The tube is about 65 feet long; and, although the moving parts of this great telescope weigh over fifteen tons, the whole is easily managed by one man, through control of several electric motors. The counter-weighted dome-floor rises and falls 23 feet, on the plan originated by Sir Howard Grubb. The photograph shows it near its lowest position. The dome is 90 feet in diameter, and weighs 140 tons.)

the best, for future great telescopes. Lord Rosse, however, adopted, not this form of universal mounting, but a modified type in which his "Leviathan" was restricted in use to small hour-angles between two north and south walls.

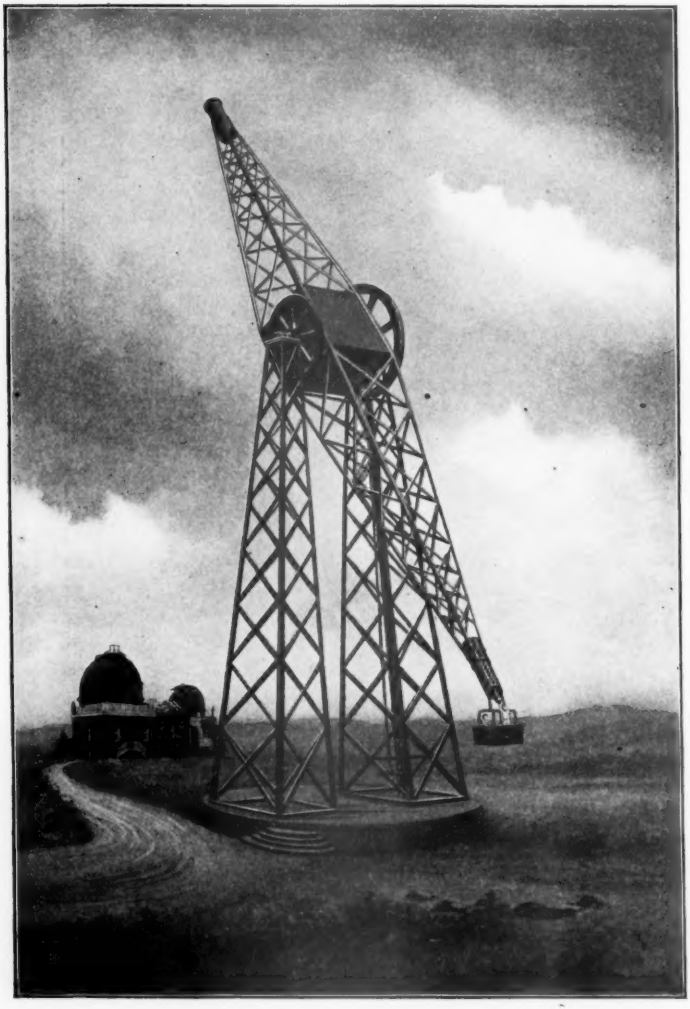


FIGURE 6.

Proposed Open-Air Refracting Telescope. Todd (1911.)

I have begun my projected telescope not at the end but in the middle, just as a bridge engineer builds a cantilever. (Fig. 6.)

The basis of its tube is a cubical section or compartment of steel plates, reinforced as in box-girder construction, so as to be absolutely rigid and unyielding. For a telescope 200 feet or 300 feet long, I would build this central cube about 20 feet square. On two opposite sides it is perforated to allow the cone of rays to pass through; and on two other sides of the cube, at right angles to the cone of rays, are attached the circular bed-plates of the bearing pins. In other words, tube and axis are the same in construction as the ordinary type of transit instrument, with shortened axis and a minimum distance between the pivots. Needless to say, this is the form which, in the evolution of transit and meridian circle, has been found to give minimum flexure.

As we are *per force* restricted to standard commercial forms of structural steel, the two halves of the tube must be built up, not as cones (the ideal form) but as square pyramids. As we have rotation about only one axis to deal with, the flexure of the great tube is easy to handle.

Mr. Spencer Miller, the eminent cable engineer, suggests the construction of a 10-foot model of this tube, from standard brass angles. Subjecting this model to known stresses and measuring up the observed flexures would afford the data necessary in deciding what forms and weights of structural steel would be best adapted to the construction of the full-sized tube. The weight of objective and cell at one end, and of observing-carriage, the observers and accessory apparatus at the other, can be accurately estimated.

It will be apparent that the alt-azimuth type of mounting follows as a necessary consequence of this evolution; and the altitude motion gives no trouble whatever in either design or practical construction; it is only when we reach the azimuth motion that mechanical and engineering difficulties arise, though they are not wholly insuperable ones.

As we go downward from the telescope to the ground, our troubles increase; and they become a maximum when we reach the plane of junction between earth and mounting. Let us now consider the method of dealing with this problem.

Apparently a simple one, it admits of several solutions at first sight practical, but which would actually prove infeasible on trial. The most obvious plan is the one adopted in Sir

William Herschel's mounting. Modern ball-bearings provide a vast improvement on the Herschelian construction; but the weakest member of the whole scheme is the horizontal, circular track, which must be at least 50 feet in diameter. To true up this track to a perfect jointless horizontal plane, and maintain it so, is a practical mechanical impossibility: at least I have not found any mechanical engineer who would undertake either to do it or to suggest a certain way of accomplishing it. Easy enough it is to think such an ideal steel track into existence, but to build one that will stay so is quite another affair. Mounting and adjusting the rollers in a circular race offer no great difficulties; in fact, Mr. Henry Hess of the Hess-Bright Manufacturing Company of Philadelphia, and his corps of able engineers, have worked out the bearing details of at least two feasible designs. In these the rollers are attached to the horizontal base-member supporting the two upright pyramidal towers on which rest the Y's of the horizontal altitude axis.

The simplest and least expensive of the three Hess-Bright designs for rotating motion of the azimuth-base would utilize 50 commercial car-wheels with ball-bearing mounts, and traveling on a 90-pound rail track about 76 feet in diameter. But the best design and the easiest working one is an adaptation of the "Grubb live-ring" with coned rollers of large diameter, their axles turning in ball-bearings and the live-ring traveling with half the speed of the plate itself.

Another plan which presents some advantages would involve the inversion of this design, the rotatory track attached to the underside of the base plate being trued off on its lower side. The supporting wheels would then be themselves stationary, and adjustment vertically as well as horizontally and radially would be facilitated.

But all these designs would offer serious difficulties in actual construction and operation. (1) To make a circular track so near a perfect plane that the load would be evenly distributed among the rollers. In experience with the 35-foot dome of Amherst College Observatory, supported on 14 rollers with an average weight of a ton on each, I have found equable distribution of the load by no means easy, and oftentimes one or two rollers travel part way round as "idlers." With the number of rollers increased to 50, as in the proposed telescope, I think the obstacles to equable load would be very greatly enhanced. (2) To preclude overturning of the entire structure by wind-thrust, a track on the upper side of the base plate

would be necessary; and trued up in a plane absolutely parallel to that on its underside. (3) The wind-thrust on the central pintle might prove so great as to deform it, and thus enforce expensive and time consuming repairs. (4) It is absolutely necessary that the whole structure, weighing perhaps 50 tons, shall turn with perfect smoothness and unvarying resistance, so that the clock-motion in azimuth may drive it with a positive motion and with that uniformity of speed-variation requisite to maintain the telescope's collimation line always coincident with the star's vertical circle.

Temperature adjustment of the base-plate offers no serious difficulty, as the entire plate is readily enclosed within a weather-proof house, in the same manner as the dome at Amherst is sealed against the smoke, dust, fog and temperature-fluctuations of the outer air; that is, by means of a thick hair-felt diaphragm which slips round on a stationary ring faced with planished copper. Also by mounting the vertical towers symmetrically on the base-plate, the stresses in it become very favorable for preventing its deformation.

All the above mentioned Hess-Bright designs contemplate the sustentation of the entire load upon the rollers. As this load need not exceed a ton on each, there is no reason whatever to fear that the whole structure might not turn round with ease, and with some approach to entire smoothness. I am, however, doubtful about its being the best method, even if the principle of flotation were added.

The cardinal objection to this whole plan, which Herschel was the first to employ, lies in the circular horizontal track. In practical use, it would always be accumulating dust, and any defect of precise radial adjustment of the axes of the rollers would give rise to variable friction. This is wholly unallowable, unless the clock-motion is a motor with excessive reserve power.

Let us see if we cannot get along without the horizontal track entirely. What we want is an absolutely smooth, positive and yet exceedingly easy motion of a huge vertical shaft. In order to meet those requisites, and treating it as a shaft simply, we should extend its length downward, and confine its motion as a journal between two horizontal friction rings, slipping between roller bearings on vertical axes. These rings with perhaps 100 roller bearings for each, 50 outside and 50 in, should have horizontal wheels or rollers of large diameter, ground to perfect cylinders. These rings are intended to oper-

ate only when the telescope is in use in the wind. When the air is still, a smoother azimuth motion would be possible if the friction rings are clamped motionless to the concrete well in which the vertical drum revolves.

Then I would float the structure in either oil or water, leaving only a few hundred pounds of load on a central button or pintle. In this way a clock of minimum power would suffice to drive a maximum load with perfect smoothness. The expanded vertical axis, then would be a little like the inner tank of a gasometer when at its lowest point. It should be not less than 50 feet in length, or vertical height; and this drum-shaped form would afford an easy interior construction, insuring absolute rigidity of the vertical towers, which might go down through it, as far as thought best. No wind could ever topple the structure over, and the open air telescope would be safely usable on all but the windiest occasions. By lowering the pintle underneath and pumping out enough of the flotation to allow the drum to settle down to stationary beds, the drum could be rigidly clamped near the top and bottom, so as to withstand securely all stormy weathers when not in use. In case of a severe gale, the telescope would be pointed quartering to the wind, observing carriage and tail-piece unshipped, and tube directed to the nadir. Here the objective would be double-housed against the storm and the cell clamped firmly. This would secure both bearings and open-air pyramids against harmful stress due to excessive wind-thrust, as the gale would strike the structure edgewise.

I have not intended in this paper to deal with the solution of any but the most general problems of this proposed telescope. All details have, however, been critically worked out, so that an approximate estimate of cost is available. A 5-foot objective would cost about $125,000, and the entire instrument would represent about double that amount. For instance, the weather-protection of the objective and eyepieces, of altitude bearings and of altitude clamp, quick motion and slow motion; also electric motors for operating the same in both coördinates, and for the requisite variable clock-motion in both altitude and azimuth, as well as for driving the rotary tail-piece on a ball-race. With this arrangement, and an adaptation of Professor Ritchey's double-slide plateholder with independent rotary motion, micrometric work and even precision photography might be quite practicable. All the clamps and motions and clocks may be controlled by electric motors operated from

triplicate switchboards in (1) the observing box (2) the altitude house (not shown on the upright piers), and (3) from the azimuth room concealed beneath the basal drum.

In lieu of observing-chair or rising-floor, observer and assistant ride in a light carriage on the eye-end, swinging on a horizontal ball-bearing axis which passes through the focal plane. This may be wholly enclosed for weather protection, and it can readily be warmed electrically in winter. Should such an instrument ever be erected on a high mountain, as for instance Fuji-yama in Japan, 12,400 feet elevation, where a saddle within the crater provides an ideal location such that wind would rarely shake the telescope, it would be wholly feasible, in fact very easy, to supply the observing-box with air artificially compressed to sea-level tension. Thereby we should avoid the disastrous effect of mountain sickness, which not only interferes greatly with ones comfort at elevations much in excess of 10,000 feet, but in consequence of the quickened pulse, tends to shorten the life-span of anyone who persists in tarrying long at great elevations, without frequent return to safe and lower altitudes.

Only the open-air alt-azimuth is discussed in the present paper. On the successful construction of such an instrument, an equatorial of similar type would be found easy to design and construct on a mountain side sloping poleward. The best design would be a lengthened polar axis, with adequate flotation drums near each end, and a forked overhanging head, very similar to the alt-azimuth design here given, only more strongly braced, and in which no added weight is requisite for declination counterpoise.

Observatory: Amherst College.
April 22, 1911.

LIFE IN OTHER WORLDS.*

H. C. WILSON.

The question asked of the astronomer, more frequently perhaps than any other by the average visitor to an observatory is that concerning the "man in the moon." Though

* Read before the Astronomical Society of the Pacific, March 25, 1911. Reprinted from Pub. Ast. Soc. of the Pacific Vol. XXIII No. 136.

jokingly asked in general, and sometimes in all seriousness, it always implies a serious question, which naturally arises in the mind of one who thinks on things celestial, concerning the possibility of life like our own in other worlds. Are all the planets which circle around the sun, or any of them, the abodes of living, sentient beings? Are those beings like ourselves? Are they engaged in similar pursuits? Do they till the soil, sow and reap, buy and sell and get gain? Have they learned men, prying into the secrets of the universe with microscope and telescope? Are they looking down at us and wondering whether on this little earth we know as much as they do? Or, among the millions of orbs which sweep through limitless space, is the little world on which we stand the only one which has been honored by the Creator with the creation of "man in his own image"?

Fruitless questions these, you may say, which it is impossible to decide. True. Still, these are things we would like to know and we shall be justified in throwing all the light we can upon them. Of late the studies of the planet *Mars* have drawn attention to the similarity of its physical condition to that of the earth, and there have been suggestions of methods of interplanetary communication. The newspapers a few years ago circulated reports to the effect that a certain astronomer had seen lights flashing from *Mars* in such a manner as to suggest to him a system of signals; in other words, that the Martians were attempting to telegraph to the inhabitants of the earth, or some other planet, after the manner of our army signal service. Though this was all a hoax, the thought has been taken up, partly in jest, partly in earnest, and schemes have been suggested for signaling back to the Martians by series of flashes from powerful condensers at the extremities of a great triangle upon the earth's surface. One lady was so impressed by these suggestions that at her death she left the sum of 25,000 francs to the Institute de France, to be used in carrying out the experiments. Of course nothing could come from such attempts, and I do not suppose they will ever be made, but the thoughts are interesting and might be made the basis of a popular novel.

Into the *a priori* arguments in favor of or against the belief that the other planets are inhabited I have not time to enter. The principal argument in favor is that from analogy. Everywhere in the earth we find evidence that the purpose of its creation was to sustain life. The planets are like the earth,

and therefore must have been made for the same purpose. The stars are like the sun, and doubtless like it have planets revolving about them; and so throughout the infinite universe "the heavens declare the glory of God" through the medium of infinite myriads of living souls, each capable of rendering the homage due to its Maker, and of comprehending to a limited extent His wondrous works. On the other hand, to some minds it does not seem at all necessary to the glory of God that His works should be seen and appreciated by human eyes.

The elaboration of these two views would be exceedingly interesting, but I must confine myself to the discussion of the facts, which have been derived from observations with telescope and spectroscope, concerning the physical condition of the planets, and their bearing upon the question of habitability. I say habitability, for I do not think we shall ever be able to say positively that any of the planets *are actually inhabited.* We shall by no increase of magnifying and defining power of telescopes ever be able to actually *see* the inhabitants. This is not because we have reached the limit of magnifying power, but because of the great turbulent ocean of atmosphere through which we must look, and which is almost incessantly in motion, bending and intermingling the rays of light which come to us, so that the minute details of a planet's surface are hopelessly blurred. The more we magnify them the worse they are blurred. On exceedingly rare occasions this sea of air quiets down and permits the astronomer to use the full power of his instrument. The astronomer is happy if at these times he is free to devote his attention to those objects which are most attractive to the sight. Occasionally such opportunities come to us at Goodsell Observatory. One in particular I call to mind. Visitors were present, and soon the clouds came over, but in the few minutes granted to us we saw minuter detail in the depths of some of those giant craters on the moon than we had ever seen before. Fine, however, as these details were, they were far too coarse to indicate the presence of men, or elephants, or even individual houses and trees. With the highest power we can use on our 16-inch telescope, the moon is brought within one hundred and fifty miles, i. e. its apparent size in the telescope is as large as it would be to the naked eye if the moon were actually one hundred and fifty miles away. The great Lick telescope in its favorable position on a mountain, above the worst of the atmospheric disturbances, will

at best bring the moon within sixty miles. You know how little can be seen at that distance. A man, to be seen with the unaided eye, must be within ten miles distance. Theoretically, a telescope could be constructed of sufficient power to bring the moon within ten miles, but at the summit of the highest mountain on the earth, there would still be air enough (as well as sufficient lack of air) to prevent its use. We must then give up all hope of seeing living beings on the moon, our nearest neighbor, much more so on the other planets.

Inquiring into the physical conditions of the planets, as suitable to the sustenance of life or not, we find first upon the moon *no air*. At least the atmosphere is thinner than that in the most perfect vacuum which we can produce by means of an air-pump. The rays of light from stars, when the moon passes them, suffer no change, either of intensity or direction, until they are instantly cut off by the solid edge of the moon. There are no clouds and no water. Air and water have apparently all been absorbed into the solid crust of our satellite. Without air and water, no vegetation can exist. There is no soil other than volcanic ashes. The surface is exceedingly rough and broken, the greater portion completely covered with crater rings and cones, lava ridges and mountains. Great yawning cracks and chasms abound, thousands of yards wide and of unknown depth. The temperature is intensely cold. The rays of the sun beat down fiercely upon the surface unrestrained by the blanket of air and vapor which on the earth both tempers and retains the heat, but the absence of this blanket allows the heat on the moon to be almost immediately radiated into space. According to the most recent investigations, the temperature of the lunar surface even during the long day (fourteen of our days) of continuous sunshine does not rise above the freezing point. And during the equally long night it must fall appallingly low. Surely this is not the place to look for life like ours.

The sun, I suppose, may be left out of consideration. A ball of gas, having a surface temperature estimated at about 10,000° Fahrenheit, would not be likely to be a comfortable place to live. Yet the theory has been entertained, by so great an authority as Sir William Herschel, that there might be a cool body within the sun, protected in some way from the intense heat of the exterior, so that life would be possible and comfortable. What kind of an envelope could possibly be

sufficient to protect the interior from the immense radiation of the exterior, which is found to be about 10,000 horse-power per square foot, has not been satisfactorily explained.

Passing outward from the sun, the first planet we come to is *Mercury*. Until recently but little was known of the physical condition of this planet. Its orbit is so near the sun that observations of its surface are obtained only with difficulty and under unfavorable circumstances. In 1881-2, however, Schiaparelli succeeded, by midday observations in the transparent sky of Italy, in identifying certain markings on *Mercury*'s surface which led him to the conclusion that the planet rotates upon its axis in the same time that it revolves about the sun, thus keeping always the same side toward the sun. More recently this conclusion has been verified by Lowell's observations at Flagstaff, Arizona, and it is probably to be accepted as a fact, although it is not yet admitted by all astronomers. If it be true, this fact has an important bearing upon the subject we are discussing. If the planet always keeps the same side toward the sun, there will be on the one hemisphere eternal day, on the other everlasting night. We can imagine what would be the effect upon the earth if the sun were to stop its diurnal course through the sky and become stationary near the zenith. Without the alternation of day and night, a continuous noon-day sun boiling down fiercely year after year would raise the temperature to a frightful height. Multiply the intensity of the rays of the tropical midsummer sun by nine and you will have some idea of those which beat down upon the sunward side of *Mercury*. On the other side would be the opposite extreme, unbroken night and a temperature practically as low as that of space, On the margin of the two hemispheres would be a zone 47° wide which would be alternately in sunshine and in darkness in the period of the planet's revolution, eighty-eight days. The sun does not stand stock still in the sky, but nods back and forth, east and west, through an arc of 47°, because of the planets varying speed in its quite elliptic orbit, while its rotation is uniform. We perhaps might suppose that the middle portion of this zone of alternate sunlight and darkness might be endurable by beings like ourselves, so far as heat and cold are concerned, but it is probable that *Mercury*, like the moon, has little if any air and water. Having only one twenty-first of the mass of the earth, *Mercury*'s gravitation is theoretically insufficient to retain much of an atmosphere, and according to Lowell's

observations, there is no visible evidence of any, for the markings which are seen are unobscured by haze or cloud on the planet. We must, therefore, conclude that *Mercury* is not habitable.

Next outward from the sun we come to *Venus*. In size and density this planet is very like the earth, and we might expect here, if anywhere upon the planets, we should find conditions suitable for life like our own. Until recently the rotation period was thought to be almost the same as that of the earth, so that she would have the same alternation of day and night, and the fact that what markings are seen are of the dimmest, vaguest, sort argues that a dense atmosphere, perhaps filled with clouds, covers the planet. In 1889, however, Schiaparelli came to the conclusion that *Venus*, like *Mercury*, keeps the same side always toward the sun, rotating once in exactly the same time in which she completes her circuit around the sun. Lowell's more recent observations confirm this view, and spectrograms of the planet taken at Flagstaff tend to establish the fact of very slow rotation. We may, however, question the validity of a proof which depends upon spectrograms taken in midday, when the sky spectrum, i. e. the spectrum of sunlight reflected by our own atmosphere, is superposed upon that of the planet, and masks the slight inclination which the planet's rotation might produce in the spectral lines.

The orbit of *Venus* is very nearly circular, so that, if the planet rotates exactly once in each revolution around the sun, there is very little libration in longitude, and the conditions upon the sunward side and the side opposite must be even more contrasted and constant than upon *Mercury*. Professor Lowell points out that the atmospheric currents would be practically constant, the lower currents being away from the point directly beneath the sun to the point directly opposite. One effect of these conditions would be to continually carry away the moisture from the sunward hemisphere and deposit it in the form of snow and ice on the dark hemisphere. The low temperature prevailing there would cause the moisture to be frozen and so prevented largely from returning. This process kept up from age to age would finally deplete one hemisphere of its water and cover the other with a permanent coat of ice. Thus *Venus*, if these things are true, is an even more undesirable place of abode than *Mercury*.

We have not been very successful, thus far, in our attempt to find a place of comfortable abode away from the earth.

Let us try *Mars* next. Here we first find positive signs of similarity to the earth. The atmosphere of *Mars* is much less dense than that of *Venus* or that of the earth, and much more of permanent detail of surface may be seen than upon any other planet. We see here large areas of bluish green, which used to be called seas and oceans, but which are now thought to be regions where vegetation is abundant. Other large areas, covering more than half of the surface of *Mars*, are of a reddish orange color, and are thought to be great deserts. The polar regions are marked by white areas which increase and diminish with the seasons on *Mars*, aud it is very natural to call these snow caps, from the likeness of their behavior to that of the polar areas of snow and ice upon the earth. The day of *Mars* is only about forty minutes longer than ours; the year there is 687 of our days, or 669 of the Martian days. The axis of the planet is tilted out of the perpendicular to the plane of its orbit by 23° 56′, only half a degree more than the tilt of the earth's axis, so that the seasons on *Mars* will be almost the exact counterpart of our own, except that their length is nearly double ours.

The difficulties in the way of saying at once that *Mars* is habitable by beings like ourselves are three; the lack of heat from the sun; the lack of atmosphere; and the lack of large bodies of water. Being 1.4 further from the sun, *Mars* receives only half the heat that the earth does, and this fact would argue that in the absence of a dense blanket of water-vapor to retain the heat, the temperature must be extremely low, too low in fact for ice to melt at all. The change of the polar caps contradicts this, and those who argue for low temperature are forced to suggest some other substance than snow to account for the caps. Carbon dioxide has been suggested by some as a substance whose crystals are as white as those of snow, and whose temperature of crystallization is much lower than that of water. But Lowell points out that at pressures of anything like that of our atmosphere or less, carbon dioxide passes at once from the solid to the gaseous state. Water lingers in the intermediate state of a liquid. The Martian cap as it melts is surrounded by a deep blue band, which accompanies it in its retreat, shrinking to keep pace with the diminution of the cap. This is what we should expect if it were water. And if we are to bring in an extra amount of carbon dioxide, a far less increase over the amount found in the earth's atmosphere would so add to the heat

retaining power of *Mars*' atmosphere as to account for the apparently high temperature indicated by the observed seasonal changes.

Of the rarity of the atmosphere there is no question. The mass of *Mars* is so much smaller than that of the earth that the force of gravity at the surface of the planet is too weak to retain an atmosphere of anything like the density of our own. Even the most ardent advocates of the possibility of life on *Mars* admit that if one of us were to be suddenly transported to that planet, he would probably die in a few minutes because of the rarity of the atmosphere. But it is claimed that beings like ourselves might gradually become accustomed to an atmosphere much rarer than ours, and this is probably true.

That water is comparatively scarce there, is also unquestioned. The spectroscopic observations of *Mars* at Flagstaff indicate very little, if any, absorption by water-vapor, and those by Campbell at the summit of Mount Whitney show no trace of any at all. In fact, if Lowell be right, it is this very scarcity of water which has brought about the evidence which comes nearest to proving that there are actually living, intelligent beings on *Mars*. Crossing the reddish-orange regions, which are considered deserts, in all directions is a network of narrow dusky lines, which their discoverer, Schiaparelli, called *canals* (channels). They are so narrow and difficult to see that it is impossible to assign a color to them, but as they connect always with the bluish-green areas or with each other, it is probable that their color is the same as that of the large dark areas, bluish green, and is due to the same cause. They are extremely difficult to see, and many astronomers have not been able to see them at all. Others glimpse them as broader and hazier than they are drawn by Schiaparelli and Lowell. As a result there has been much doubt as to the real character of these markings. Lowell does not hesitate to explain them as lines of vegetation along artificial watercourses; not the canals themselves, but the irrigated regions on either side of the canals. From his studies at Flagstaff, Arizona, at all the oppositions of the planet since 1894, Lowell finds that the "canals" vary in visibility with the Martian season in such a way as to indicate progressive irrigation, as the water flows from the melting polar caps toward and even beyond the equator. Certain of the "canals" run north and south through the dark areas as well as the light ones, into the regions covered in winter by the polar

caps. As the cap melts in spring there first appears a blue band at its edge. After a time the canals nearest this band become visible, then later those nearer the equator, the interval between the melting of the cap and the appearance of the canals being sufficient to allow for the time required, not only for the transference of water, but also for the springing up of vegetation, after the water has reached the irrigated region. The "canals" near the equator on either side have two periods of visibility each year, corresponding to the time when the water would reach them from the two polar caps at opposite seasons of the year. The "canals" as a rule are very straight, running on arcs of great circles from point to point on the globe of *Mars*. Often several of them meet at a common point, and in many cases at the intersection of two or more of them there appears a round dark spot, to which Lowell gives the name "oasis." The apparent straightness of the "canals" has made astronomers skeptical of their reality, since on the earth watercourses, whether real or artificial, are never straight. They invariably wind about, following the contour of a level or descending line. Either *Mars* has a very flat surface or the Martians are very wonderful engineers. Perhaps both statements are true. There is no evidence of mountains on the planet, for the terminator never has the jagged appearance which the mountains produce on the sunrise and sunset lines of the moon. Clouds are very rarely conspicuous. I have sometimes seen misty patches over the dark areas, as if there were very thin clouds or fog there, but never enough to entirely obscure the surface of the planet beneath them.

On the whole we must conclude that life on *Mars* would not be very satisfactory for beings like ourselves. That there may be life there, I would not like to deny. There may be intelligent beings, of a higher order even than ourselves, but of this there is no adequate proof. Lowell in the "Conclusion" of his book "*Mars* and Its Canals," says "that *Mars* is inhabited by beings of some sort or other we may consider as certain as it is uncertain what those beings may be." With the last part of the statement we can certainly agree.

The satellites of *Mars* are so small,—not more than twenty or thirty miles in diameter,—that they must ages ago have lost all their heat and absorbed their air and water, so they are not the places for life.

Next in order, outward from the sun, we come to the giant planet *Jupiter*, with his retinue of four large satellites and four

small ones. The diameter of *Jupiter* is 86,000 miles, eleven times that of the earth, but his rotation is so swift that the Jovian day is less than ten of our hours. His average density is only one-fourth of that of the earth, i. e. a little greater than that of water. The surface is diversified by belts of red and purple and white running parallel to the equator. These do not suggest the appearance of land and water, but rather of cloud-zones, between which we see perhaps portions of the real surface. The best evidence we can get goes to show that *Jupiter* has not yet cooled off enough to have a solid surface, but that it is still intensely hot and subject to continual change. He is a sort of semi-sun, giving light and heat to his satellites to make up in part for the diminution of light and heat of the sun at their great distance.

Interesting as the astronomical phenomena as seen from *Jupiter* would be; with the eight moons circling about him, producing total lunar and solar eclipses every day, we can hardly say that the giant planet is fitted for a place of abode. It is possible that on the satellites the conditions may be more like those on *Mars* and the earth, but we can tell very little about them. The little we do know points to similarity to our own moon, which we have found to be uninhabitable.

Saturn, the king of the planets, comes next in order, with his golden rings and numerous satellites. Surely this would be a glorious place to live, with the ten moons of as many different sizes and the great arch of meteor rings spanning the heavens. But we find that *Saturn* is in much the same condition as *Jupiter*, not yet cooled off. The low density of the planet,—less than that of water,—and the brightness of its surface,—greater than that which could be produced by the reflected light of the sun,—indicate a high temperature. Of the conditions of the satellites we know almost nothing, *Titan*, the largest, approaches *Mars* in size, and might, so far as size is concerned, be an inhabited world.

The two outer planets, *Uranus* and *Neptune*, are too far from the earth to allow us to learn much of their surfaces. *Uranus* has belts like *Jupiter*. *Neptune* has no perceptible markings on his surface. Both are denser than *Jupiter* and *Saturn* and of darker color. There is one argument which seems to be pretty conclusive against the habitability of these planets and that is the diminution of the sun's light and heat at such great distances. As seen from *Neptune*, the sun would have only one-thirtieth of its present apparent diameter and would give only one nine-

hundredth as much light and heat. This would hardly be deemed sufficient to maintain life like ours.

We have omitted the asteroids, of which there are now nearly seven hundred known, and more being discovered every month, in our discussion of the condition of the planets. As the largest of these is not more than four hundred or five hundred miles in diameter, it is not probable that any of them are warm enough, or possess atmosphere enough, to sustain life.

In the whole solar system, then, we find but one planet, *Mars*, on which the physical conditions seem to be suited to life like our own, and even there our constitutions would have to be considerably modified. Some of the satellites of *Jupiter* and *Saturn* may also, perhaps, be habitable, but of the condition of these we have almost no positive knowledge.

But how about the stars? Among the thousands, millions, and hundreds of millions of glittering orbs which the great telescopes reveal, are there no inhabited worlds? We can say of each one of these, which is visible to the eye or which the telescope reveals, that it is a sun, an intensely hot, glowing body, shining by its own light and therefore not an inhabitable world. How many satellites or planets there are, circling invisible around the stars, we can only infer by analogy, and we can only infer, again by analogy, that among the myriads of these invisible satellites there may be millions of worlds like our own.

A YEAR ON MT. HAMILTON.

M. YAMASAKI.

When I first had the taste for astronomy I thought how interesting it would be to spend some months in a large observatory! Several years elapsed before this dream could be realized. Last September I received a letter from Mrs. Aitken of the Lick Observatory telling me she had work for me. No one can imagine how glad I was with that message. I arrived at the mountain top on September 3rd. The ride in an automobile stage, 28 miles on the mountain road, was interesting, but the things that most impressed me were, of course, the magnificent observatory buildings and the thought of the big

telescopes. I had somewhat imagined the beauty of the observatory through books, but the real view is more than the pen can write. The scenery of the heavens as well as that of the valley and the mountain slopes is wonderful. It was my greatest pleasure to spend several hours in the big library of the observatory where great collections of astronomical books and periodicals are.

Later, through the courtesy of the gentlemen of the Lick Observatory, I was given the privilege of using the six-inch refractor. I am very much ashamed that I have no sufficient data of the observations with this instrument. Yet I do not like to leave Mt. Hamilton without a word. I hope it will not be entirely void of interest to give the summary of my observations.

The remounting and adjustment of the 6-inch telescope was done early in January, 1911, but the weather was very bad and I could not make any observations until February 7. It was my program to work four evenings of a week, Wednesday, Thursday, Friday and Saturday. For sunspot observations I used the 2-inch finder, specially arranged with my eyepiece, which magnifies about thirty times. Whenever there were spots I made drawings. Thirty-three observations with brief remarks are given below.

1911,	Jan.	22,	No spot.
	Feb.	8,	No spot.
		18, 3 P.M.	Three very small spots in west.
		19, 3 P.M.	Same.
		22, 3 P.M.	No spot.
	March	12, noon,	No spot.
		25, 2 P.M.	No spot.
	April	1, 3 P.M.	One group in the middle, about seventeen spots; one large spot in the eastern limb.
		2, 2 P.M.	Middle group of April 1, greatly changed, spots diminished to 11. Eastern spot of April 1, became 3.
		8, 11 A.M.	One large spot in center.
		12, 2 P.M.	Spot of April 8 came to western limb.
		13, 2 P.M.	Same.
		15, 19, 20,	No spot.
		22, 2 P.M.	Three spots appeared in the eastern limb.
		23, 2 P.M.	Same spots.
		29, 3 P.M.	Three spots in west, middle one quite large
		30, "	Same.
	May	6, 3 P.M.	One group of six spots in the west.
		25, 2 P.M.	One spot in the eastern limb.

	27, 10 A.M.	Spot of May 25 became group of six spots, one quite large.
	28, 1 P.M.	Three spots in east, one quite large.
June	1, 3 P.M.	Two spots in west, one quite large.
	2, 3 P.M.	Three spots in west.
	4, 2 P.M.	One large spot in western limb.
	7, 11, 16,	No spot.
	21, 3 P.M.	Three very small spots in east.
	23, 11 A.M.	One small spot in east.
	29, 30, July 7,	No spot.

I have also observed Venus, the Moon, Jupiter and variable stars. I have made thirty-four drawings of Jupiter. Six, sometimes seven, belts were discernible; detail could not be obtained but general features were about the same throughout. The variable star observations are very interesting to me. I used an opera-glass for the observations of variable stars brighter than sixth magnitude, and the telescope for fainter stars. The total observations with the opera-glass from September 21, 1910 to July 21, 1911 for seventeen variables are 740 and with the telescope from March 25, 1911 to July 30 for sixteen variables are 160. Most of the telescopic variables are recent discoveries and their elements are not yet known. My observations are not sufficient to make any computation for the possible elements.

The most interesting observing I have done is in stellar spectroscopy. This will probably be of some interest to fellow amateurs.

Some time ago I bought a Zöllner Star Spectroscope from the John Browning Co, London. It is only 1″¾ long, having three prisms and a cylindrical lens to widen the spectrum. The use of this spectroscope is very simple. It is screwed to the eyepiece of the telescope. I used this instrument on the 6″ telescope and observed the different spectra of many stars.

Sirius shows four broad hydrogen lines, ζ, ϵ, β Ursae Majoris, β Leonis, etc., show two hydrogen lines. Aldebaran, Capella, Arcturus, γ Draconis etc., show several prominent lines of the solar spectrum. γ Cassiopeiae presents a bright line in the red. α Orionis and α Herculis are by far the most beautiful objects with this spectroscope. Their spectra show several dark bands which shade from the blue towards the red; that is, they are sharply defined and darkest at the more refrangible edge. Antares has many lines and faint dark bands, somewhat resembling those of α Orionis.

I observed the spectrum of the variable star o Ceti on the morning of July 23. My estimate of its magnitude at this time was 3.78. Its spectrum looks very much like that of α Herculis, with seven dark bands.

I observed the solar spectrum of Venus when its phase was a mere point of light, with a low power eyepiece. Figure 1 indicates the typical spectra of the stars above mentioned. This spectroscope, if care is taken, is good enough for a three-inch telescope and upward.

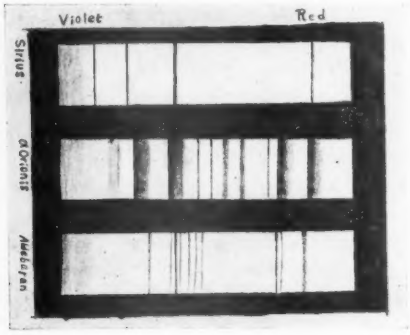


FIGURE 1.

The use of the miniature, direct vision spectroscope which I bought at the same time, is not very easy for stellar spectroscopy unless the telescope is driven by clockwork. Figure 2 shows the diagram of the adjustment I have used. Spectroscope S is put into a wooden frame F, which is put upon the eye end of the telescope. The slit is close to the eyepiece. In using this instrument, first, get the object into the center of the field of view and then slide the frame work upon the eye end. I did not find any difference with or without the eyepiece excepting in the case of the Moon observation. In this case, the eyepiece must be taken off; otherwise, the definition is poor.

By this means I observed the spectrum of Jupiter. Three lines were detected; one broad line in the red, two faint lines in the green. The one in the red is not identical with the solar line. This is one of the lines peculiar to the spectra of the major planets. On the morning of July 23, I observed the spectrum of Kiess' comet with it. I saw two bright bands.

I thought I saw three bands but was not very sure. On the morning of July 30, I again observed the comet spectrum, This time I saw three bands, the middle one the brightest. The spectrum of a comet is a comparatively easy one to observe. In the English Mechanic No. 2340, 1910, Mr. Frank C. Dennett of England wrote:

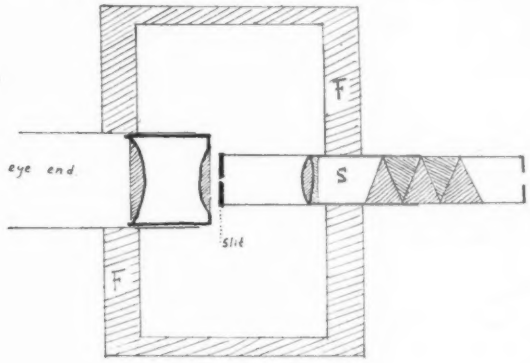


Fig. 2.

"My best vision of a cometary spectrum was obtained in a novel manner. When in 1881 two comets were visible in the northern circumpolar heavens, I had no telescope rigged up for use. I had the metal mirror of a Gregorian 5½-inch diameter by me, belonging to Mr. Calver. Fortunately, my bedroom window had a northern aspect. The large mirror was set on the bed in such a way that it sent back the comet's light at a small angle. The focal image was caused to fall on the slit plate of a Browning miniature, and the three band spectrum was easily seen."

I have also observed the spectra of nebulæ. In the constellation of Draco, very close to the pole of ecliptic, there is a very small, bright planetary nebula. This is the one that, first, in August, 1864, unveiled its mystery to the star spectroscope of the late Sir William Huggins. I turned my spectroscope to it and saw one bright line. The Zöllner spectroscope also showed the line. The ring nebula of Lyra has revealed to me a bright line also.

The maker's price of the Zöllner spectroscope is 1£ 17s 6d. So I think it is quite in easy reach of many amateurs wishing to see the different and beautiful spectra of the stars.

Thus a year on Mt. Hamilton was very interesting to me.

I have had the most enjoyable time I have ever experienced in my sojourn on the American soil. My future astronomical observation, if my plan is realized, will be done in my little observatory in my native place. A year or so will be devoted to this purpose and I hope my idea will be realized.

I take this opportunity to express my sincere thanks for the kindness of Dr. Campbell, Dr. Aitken, Dr. Curtis and other gentlemen of the Lick Observatory, and Dr. H. C. Wilson of Carleton College whose kindness impressed me also while he was in the Lick Observatory.

August 1, 1911.

THE CONJUNCTION OF MARS AND SATURN 1911 AUGUST 16.

E. E. BARNARD.

Conjunctions of Mars and Saturn are not very rare. They must occur about every two years. A close conjunction, however, is quite rare, especially one that happens when the objects are well placed for observation. Though the conjunction of 1911 August 16 was not a specially close one (distance 21′) it was sufficiently close to make it very interesting, especially because, through a fortunate combination of circumstances, our moon was also in conjunction with the two planets, thus making a beautiful and impressive picture. (See Frontispiece.)

The planets and the moon rose here in a good sky but they were soon obscured by light fleecy clouds that did not clear away until near daylight, when the sky became beautifully clear. The planets were frequently seen, however, through breaks in the clouds, at which times they shone, apparently, with a greater splendor than on a clear moonless sky. Perhaps this was due to the absence of other stars and to the framing of clouds. I have always remarked that the brighter stars generally appear more noticeable on a moonlit sky. This is doubtless due to their apparent isolation by the blotting out of the many smaller stars with the light of the moon.

Though not of any special value from a scientific standpoint, it was thought well to preserve a photographic record of this conjunction. Exposures were therefore made with the six-inch and ten-inch lenses of the Bruce telescope. A reproduction of one of these photographs made with the six-inch lens and somewhat enlarged is given with this paper. The original

negative was a Seed 30 plate. The exposure of twenty seconds duration, was made when a small patch of cloud was over the moon, which acted as a screen and reduced its brightness, the two planets being seen on a clear part of the sky. Mars appeared about ½ magnitude brighter than Saturn to the eye. On the photograph Saturn is slightly the brighter, since its photographic light was greater than that of Mars. Mars is the upper one of the two—nearest the moon. The picture was made about one hour after the nearest approach of the two planets.

To my surprise several of the exposures with the ten-inch lens, which were made on Seed 27 plates clearly show the dark part of the moon, with the details of the surface strongly marked. The moon lacked nearly seven days of being new and the shortest exposure was twenty seconds. With this exposure the earthlit part is conspicuous.

At this apparition of Mars—as in previous oppositions—one is struck with the absence of red in the planet. It is of a beautiful vivid golden color. The absence of any decided red is very marked. At greater distances however, when the planet is less bright, it appears redder because of the general dulling of its light, which seems to destroy the beautiful golden color.

The present was the closest conjunction of Mars and Saturn since that of 1889 September 19, when they were less than one minute apart. It was also a very favorable one for the northern hemisphere because the planets were 15° north of the equator and were sufficiently far from the sun to be seen at a high altitude.

Conjunctions of Mars and Saturn.

Date	Dist. ° ′
1889 Sept. 19	0 1
1891 Oct. 12	0 52
1893 Oct. 31	1 36
1895 Nov. 16	1 59
1897 Nov. 27	2 2
1899 Dec. 6	1 48
1901 Dec. 13	1 19
1903 Dec. 20	0 33
1905 Dec. 25	0 30
1907 Dec. 30	1 50
1909 Dec. 31	3 12
1911 Aug. 16	0 21
1913 Aug. 24	1 9

The foregoing, which may be of interest, is a list of the times of conjunction of Mars and Saturn from 1889 to 1913 and the apparent distances between the planets, as collected from the *American Ephemeris.*

Of these the closest approach (and the closest on record, apparently) was that of 1889 September 19.

In the *Monthly Notices of the Royal Astronomical Society* for June 1889 (Vol. xlix p. 424) Mr. A. Marth in writing of the then approaching close conjunction (September 19) of Mars and Saturn says:

"The tabular places of the two planets give the nearest geocentric approach of their centers 54″.8 at $20^h\ 7^m$ Greenwich mean time, so that the conjunction will be a closer one than that of June 30, 1879, when the shortest distance between the nearest limbs was 74″, according to the Melbourne observations, *Monthly Notices*, vol. xl. p. 30. The next close conjunction preceding that of 1879 took place on April 18, 1817, but was not observable at any then existing observatory, and of any previous close conjunction there is at least no record."

At the conjunction of 1879 both Mr. Ellery and Mr. White at Melbourne repeatedly measured the distance between the planets while they were approaching and until they were separating. Mr. White's measures at $17^h\ 12^m\ 55^s$ Melbourne M.T. showed that the distance between the centers of the planets was 86″.4. Unfortunately neither observer gives any record of the naked eye appearance of the planets—as to whether they were separately seen or not at the closest approach.

The only observations (besides those made by myself) that I have been able to find of the very close conjunction of 1889 September 19 were those made in England by Major S. H. Maxwell, and by Mr. E. W. Maunder who observed at Greenwich (M. N. Vol. L. pp. 34 to 36.) In these observations the planets were lost in daylight several hours before the closest approach. The shortest distance measured by Major Maxwell was 122″.5 at $18^h\ 41^m\ 36^s$ G.M.T. while that of Mr. Maunder was $\Delta\alpha$ (Mars—Saturn)—$9^s.65$ and $\Delta\delta - 1'\ 47''.6$ at $17^h\ 59^m$ G.M.T. Nothing is said of the appearance of the two planets with the naked eye. According to Mr. Marth the nearest approach was at $20^h\ 7^m$ G.M.T. The closest approach ($14^h\ 59^m$ Washington M.T.) could have been observed in the eastern part of the United States, but I have been unable to find any record anywhere of such observations. The failure to observe these planets at that time was a great pity, because the naked eye observations alone would have been of the greatest value, for Mars and Saturn perhaps appeared as one at the closest approach and a record of the times when they ceased to be dis-

tinctly separate or again became separate would have been of great value in interpreting records of this kind made before the invention of the telescope.

When the planets rose at the Lick Observatory on 1889 September 19 they were well separated to the eye. The position angle and distance of the two were repeatedly measured. They were then separating rapidly and at $16^h\ 34^m\ 19^s$ Mount Hamilton mean time the distance between their centers was 358″.8 or a little less than six minutes of arc. (*Publications of the Astronomical Society of the Pacific* Vol I. p. 82.)

Yerkes Observatory,
Williams Bay, Wis. Sept. 13, 1911.

PLANET NOTES FOR NOVEMBER, 1911.

C. H. GINGRICH.

The sun will move from 14° 10′ south latitude on November 1 to 21° 31′ south latitude on November 30. It will consequently rise and set farther south each succeeding day, and in the northern hemisphere the days will become shorter. The sun will also move east through the constellation Libra and into Scorpio, and at the end of the month it will be almost exactly north of and only a few degrees away from the bright star Antares, which will then be invisible because of the proximity of the sun.

The phases of the moon for this month are as follows:

Full Moon	Nov. 6
Last Quarter	" 13
New Moon	" 20
First Quarter	" 29

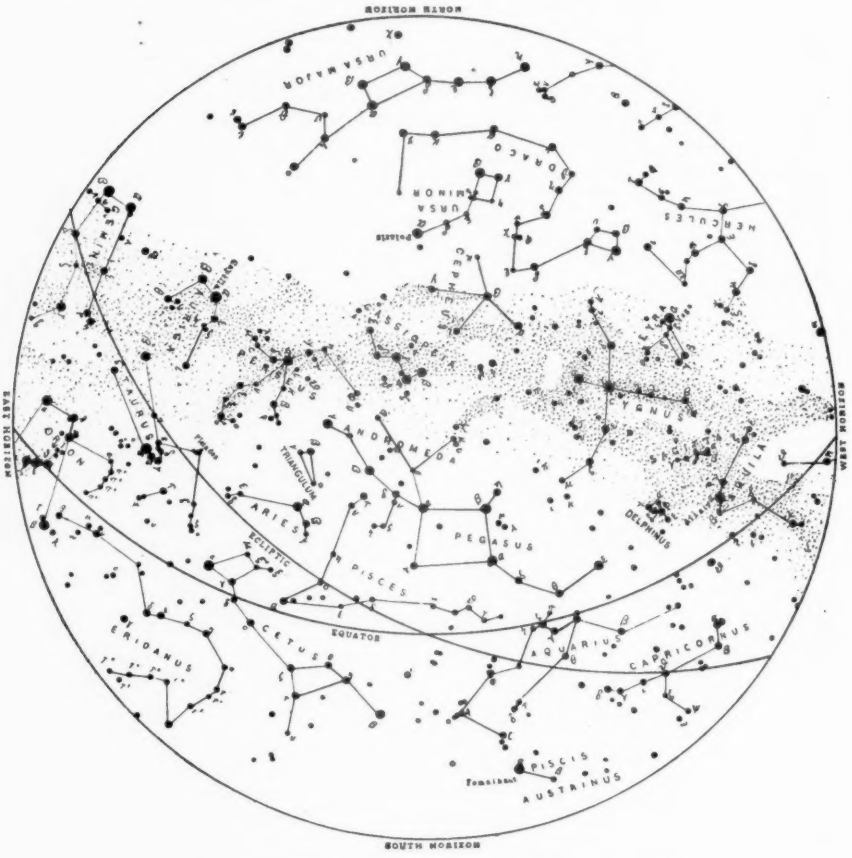
The moon will reach its period nearest the earth on November 8, and will be farthest from the earth on November 24.

Mercury at the beginning of the month will be very near to the sun, being only about 1.4° east. It will move eastward more rapidly than the sun during the month, and by November 30 it will be approximately 20° east of the sun. At this date it will be a few degrees south of the sun and will be visible low in the south west immediately after sunset.

Venus will move south during the month, crossing the ecliptic on November 6. It will be considerably west and north of the sun throughout the month and will be a bright object in the eastern sky before sunrise. It will reach its greatest distance west of the sun on November 25, on which date it will be approximately three hours from the sun. It will be moving away from the earth and will be becoming less brilliant.

Mars will be especially interesting during this month because of its near approach to the earth. It will reach its nearest point on November 17. At this time it will be less than fifty million miles from the earth. It will be in opposition on November 24, that is, on this date the sun, earth and Mars,

except for the inclination of the orbits of the earth and Mars, will be in the same straight line, the earth being between the other two. It will therefore be in a very favorable position for study this month, and will rise at or near the time of sunset and be visible throughout the night.



THE CONSTELLATIONS AT 9:00 P. M. NOVEMBER 1, 1911.

Jupiter will be so near to the sun as to be invisible during this month. It will be in conjunction on November 18, that is, on this date it will be directly behind the sun from the earth except for a slight difference in declination, Jupiter being a very little north of the sun. This phenomenon cannot be observed because of the great brightness of the sun. Jupiter will of course, be a very great distance beyond the Sun.

Saturn will be in opposition to the sun on November 9. It will consequently be above the horizon nearly all night during the month and will be

perhaps the most interesting object in the sky to look at. On this date it will be about eight times as far away from the Earth on one side as the sun is on the other.

Uranus will be moving eastward slowly between Sagittarius and Capricornus. It will be a few hours east of the sun and will be visible in the south west shortly after sunset.

Neptune will be moving slowly westward in the constellation Gemini. It will be visible in the morning. It will rise a little before midnight.

Occultations visible at Washington.

Date 1911		Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	Angle f'm N. °	EMERSION. Washington M.T. h m	Angle f'm N °	Duration h m
Oct.	2	86 B Capricorni	6.2	9 56	110	10 47	192	0 51
	3	145 B Capricorni	6.1	9 43	60	11 03	232	1 20
	5	ψ^2 Aquarii	4.6	8 24	351	8 59	298	0 35
	7	*e* Piscium	5.6	17 17	67	18 14	240	0 57
	9	29 Arietis	6.1	5 56	38	6 40	271	0 43
	9	π Arietis	5.2	15 04	26	16 06	277	1 02
	9	ρ Arietis	5.6	18 46	59	19 42	267	0 56
	10	14 H′ Tauri	6.5	10 03	125	10 30	178	0 28
	10	133 B Tauri	5.9	16 18	115	17 13	209	0 55
	12	136 Tauri	4.6	14 24	78	15 43	262	1 19
	12	415 B Tauri	6.1	18 40	117	19 48	250	1 07
	14	ω^1 Cancri	6.0	14 24	169	14 43	200	0 19
	29	40 B Capricorni	6.2	9 14	99	10 11	209	0 57
	30	33 Capricorni	5.3	10 33	1	11 09	298	0 36
	31	161 B Capricorni	6.4	2 26	30	3 18	292	0 52
Nov.	4	263 B Piscium	6.4	11 43	75	12 52	213	1 09
	7	62 Tauri	6.1	13 38	133	14 16	191	0 38
	9	49 Aurigae	5.1	12 52	16	13 19	332	0 27
	12	57 B Leonis	6.5	14 21	58	15 04	344	0 44
	27	154 B Capricorni	6.1	7 20	55	8 36	236	1 16
	29	ψ^2 Aquarii	4.6	2 32	351	2 56	312	0 23

The Rotation of Venus.—The following is a translation of a note by M. Bigourdan in the *Comptes Rendus* of July 3, relative to a recent determination of the period of rotation of Venus, by means of the displacement of lines of the spectrum:—

In 1900 M. Belopolsky had found that the length of this rotation (of Venus on her axis) is short, a little more than a day. This conclusion being in contradiction with that which Mr. Slipher had arrived at in 1903, the question remained in suspense. M. Belopolsky has continued his researches upon the same subject, and his results of 1903, 1908 and 1911 have confirmed those that he had obtained previously. He has moreover, verified his instrument by means of Mars, the duration of whose rotation is known, and he found for its equatorial velocity 0.354 per second instead of 0.254 km. The value found for Venus, 0.38 km., corresponds to a period of rotation 1.44 days (*The Observatory* August 1911.)

Annular Eclipse of the Sun.—An annular eclipse of the sun will take place on October 21 but will not be visible in America. The path of the annulus will cross from the Aral Sea over the south central part of Asia, between Borneo and the Phillipine Islands, across New Guinea, to a point in the Pacific Ocean northeast of Australia (For chart see the January 1911 number of POPULAR ASTRONOMY). The greatest duration of the annular phase will be $3^m\ 52^s$.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Sept. 1, 1911.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn
X Androm.	0	10.8	+46	27	9.8	R Ophiuchi	17	2.0	−15	58	<11
T Cassiop.		17.8	+55	14	8.8	Z Ophiuchi		14.5	+ 1	37	8.8 *i*
W Cassiop.		49.0	+58	1	11.9*d*	T Herculis	18	5.3	+31	0	8.5 *i*
U Androm.	1	9.8	+40	11	<13	W Draconis		5.4	+65	56	11.5 *i*
— Androm.		10.4	+41	12	<13	X Draconis		6.8	+66	8	10.3 *i*
S Cassiop.		12.3	+72	5	<11	W Lyrae		11.5	+36	38	<10
RU Androm.		32.8	+38	10	<12	SV Draconis		31.2	+49	18	<12
Y Androm.		33.7	+38	50	9.5	RY Lyrae		41.2	+34	34	9.1
RR Persei		21.7	+50	49	11.5*d*	Z Lyrae		56.0	+34	49	9.7
W Persei		43.2	+56	34	9.0	V Lyrae	19	5.2	+29	30	<12
X Camelop.	4	32.6	+74	56	9.1*d*	U Lyrae		16.6	+37	42	10.3
V Camelop.	5	49.4	+74	30	10.0	χ Cygni		46.7	+32	40	4.7
R Urs. Maj.	10	37.6	+69	18	<11	RS Cygni	20	9.8	+38	28	7.6
T Urs. Maj.	12	31.8	+60	2	8.9*d*	R Delphini		10.1	+ 8	47	9.8*d*
S Urs. Maj.		39.6	+61	38	8.5 *i*	V Sagittae		15.8	20	47	12.0
R Can. Ven.	13	44.6	+40	2	7.1 *i*	U Cygni		16.5	+47	35	<11
U Urs. Min.	14	15.1	+67	15	8.8*d*	T Aquarii		44.7	− 5	31	<10
S Boötis		19.5	+54	16	12.0*d*	R Vulpeculae		59.9	+23	26	<10
R Camelop.		25.1	+84	17	<11	T Cephei	21	8.2	+68	5	6.6
R Boötis		32.8	+27	10	7.1 *i*	R Equulei		8.4	+12	23	10.1*d*
S Cor. Bor.	15	17.3	+31	44	11.0*d*	S Cephei		36.5	+78	10	<11
R Cor. Bor.		44.4	+28	28	<11	S Aquarii	22	51.8	−20	53	<10
X Cor. Bor.		45.2	+36	35	<12	R Pegasi	23	1.6	+10	0	<10
U Serpentis	16	2.5	+10	12	9.6 *i*	V Cassiop.		7.4	+59	8	11.0*d*
RU Herculis		6.0	+25	20	10.9*d*	— Androm.		33.8	+35	13	9.7
W Cor. Bor.		11.8	+38	3	12.1*d*	R Aquarii		38.6	−15	50	8.5
R Draconis		32.4	+66	58	8.1*d*	Z Cassiop.		39.7	+56	2	<13
S Herculis		47.4	+15	7	11.3*d*	R Cassiop.		53.3	+50	50	10.6*d*
RV Herculis		56.8	+31	22	10 2 *i*						

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made at the Amherst, Olcott, and Jacobs, Observatories.

Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time beginning with noon. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours, etc. For stars marked thus * alternate minima are given; ** every third minimum; † every tenth minimum.]

SY Androm.

	d	h
Nov.	26	9

*U Cephei

Nov.	1	14
	6	14
	11	14
	16	13
	21	13
	26	13

*Z Persei

Nov.	3	7
	9	10
	15	12
	21	15
	27	18

RY Persei

Nov.	1	8
	15	2
	28	19

**RZ Cassiop.

Nov.	2	3
	5	17
	9	7
	12	21
	16	12
	20	2
	23	16
	27	6
	30	20

*ST Persei

Nov.	4	16
	9	23
	15	6
	20	13
	25	20

RX Cephei

Nov.	12	3

*β Persei

Nov.	1	13
	7	7
	13	1
	18	18
	24	12
	30	7

**RT Persei

Nov.	2	22
	5	11
	8	0
	10	13
	13	2
	15	15
	18	5
	20	18
	23	7
	25	20
	28	9
	30	22

λ Tauri

Nov.	3	12
	7	11
	11	10
	15	8
	19	7
	23	6
	27	5

*RW Tauri

Nov.	3	7
	8	20
	14	9
	19	22
	25	11

Minima of Variable Stars of the Algol Type.—Continued.

*RV Persei

	d	h
Nov.	4	21
	8	20
	12	18
	16	17
	20	16
	24	15
	28	13

RW Persei

Nov.	3	23
	17	4
	30	9

RS Cephei

Nov.	10	6
	22	16

*RY Aurigae

Nov.	3	0
	8	11
	13	22
	19	9
	24	20
	30	7

*RZ Aurigæ

Nov.	5	8
	11	9
	17	10
	23	11
	29	11

51.1908 Gemin.

Nov.	2	16
	6	16
	10	16
	14	16
	18	16
	22	16
	26	17
	30	17

*RW Gemin.

Nov.	1	20
	7	14
	13	7
	19	1
	24	18
	30	12

*U Columbæ

Nov.	6	0
	11	15
	17	5
	22	19
	28	10

*RW Monoc.

Nov.	3	16
	7	11
	11	7
	15	2
	18	22
	22	17
	26	13
	30	8

RX Gemin.

Nov.	8	17
	20	22

**RU Monoc.

	d	h
Nov.	1	8
	4	0
	6	17
	9	9
	12	2
	14	18
	17	11
	20	3
	22	20
	25	12
	28	5
	30	21

**R Canis Maj.

Nov.	4	6
	8	0
	11	2
	14	12
	17	21
	21	7
	24	17
	28	3

RY Gemin.

Nov.	4	7
	13	14
	22	22

*Y Camelop.

Nov.	3	4
	9	17
	16	10
	23	0
	29	15

RR Puppis

Nov.	1	22
	8	8
	14	19
	21	5
	27	15

**V Puppis

Nov.	2	22
	7	7
	11	15
	16	0
	20	9
	24	18
	29	2

†X Carinæ

Nob.	6	8
	11	18
	17	4
	22	14
	28	0

S Cancri

Nov.	2	19
	12	7
	21	19

S Velorum

Nov.	5	18
	11	16
	17	14
	23	13
	29	11

**Y Leonis

	d	h
Nov.	1	17
	6	19
	11	20
	16	21
	21	23
	27	0

**RR Velorum

Nov.	3	0
	8	14
	14	3
	18	17
	25	6
	30	20

*SS Carinae

Nov.	1	12
	8	3
	14	17
	21	8
	27	22

RW Urs. Maj.

Nov.	5	14
	12	22
	20	6
	27	14

**Z Draconis

Nov.	3	6
	7	8
	11	9
	15	11
	19	13
	23	15
	27	16

*SS Centauri

Nov.	1	15
	6	14
	11	13
	16	12
	21	11
	26	9

*δ Libræ

Nov.	1	17
	6	9
	11	0
	15	16
	20	8
	24	23
	29	15

*U Coronæ

Nov.	3	2
	9	23
	16	21
	23	19
	30	16

*SW Ophiuchi

Nov.	1	18
	6	16
	11	13
	16	10
	21	8
	26	5

*SX Ophiuchi

	d	h
Nov.	3	8
	7	11
	11	14
	15	17
	19	20
	23	23
	28	2

R Aræ

Nov.	3	5
	7	15
	12	1
	16	12
	20	22
	25	8
	29	18

**U Ophiuchi

Nov.	1	14
	4	3
	6	15
	9	3
	11	16
	14	4
	16	16
	19	5
	21	17
	24	6
	26	18
	29	6

**SZ Herculis

Nov.	1	18
	4	5
	6	16
	9	3
	11	14
	14	1
	16	12
	18	23
	21	10
	23	20
	26	7
	28	18

Z Herculis

Nov.	2	0
	6	0
	10	0
	13	23
	17	23
	21	23
	25	23
	29	23

SX Draconis

Nov.	5	6
	10	10
	15	15
	20	19
	25	23

*RS Sagittarii

	d	h
Nov.	3	18
	8	14
	13	10
	18	6
	23	2
	27	22

*V Serpentis

Nov.	3	8
	10	6
	17	4
	24	1
	30	23

†RZ Draconis

Nov.	5	20
	11	8
	16	20
	22	8
	27	21

** RX Herculis

Nov.	1	22
	4	14
	7	6
	9	22
	12	14
	15	6
	17	22
	20	14
	23	6
	25	22
	28	14

*SX Sagittarii

Nov.	5	3
	9	7
	13	11
	17	14
	21	18
	25	22
	30	1

*RR Draconis

Nov.	4	8
	10	0
	15	16
	21	8
	27	0

**U Scuti

Nov.	1	15
	4	11
	7	8
	10	5
	13	2
	15	22
	18	19
	21	16
	24	13
	27	9
	30	6

Minima of Variable Stars of the Algol Type.—Continued.

*RX Draconis		*Z Vulpec.		VW Cygni		RR Vulpec.		WZ Cygni	
d	h	d	h	d	h	d	h	d	h
Nov. 4	6	Nov. 2	9	Nov. 8	21	Nov. 1	20	Nov. 2	15
8	1	7	6	17	8	6	21		
11	20	12	4	25	18	11	23	*RT Lacertae	
15	15	17	2			17	0	Nov. 2	9
19	10	22	0	*UW Cygni		22	1	7	11
23	5	26	22	Nov. 4	1	27	2	12	13
27	0			10	23			17	15
30	19	SY Cygni		17	20	**VV Cygni		22	16
*RV Lyræ		Nov. 6	17	24	18	Nov. 3	9	27	18
Nov. 2	14	12	17			7	19		
9	19	18	17	W Delphini		12	5	*TT Androm.	
16	23	24	17	Nov. 5	16	16	14	Nov. 3	4
24	4	30	17	10	11	21	2	8	17
16.1908 Vulpec.				15	6	25	12	14	6
Nov. 2	19	*WW Cygni		20	2	29	23	19	18
7	7	Nov. 2	12	24	21	**28.1910		25	7
11	18	9	4	29	17	Cygni		30	20
16	6	15	19			Nov. 1	19		
20	17	22	10	RR Delphini		4	16	21.1909 Andr.	
25	5	29	1	Nov. 1	10	7	14	Nov. 4	5
29	16			6	1	10	12	8	7
*U Sagittae		SW Cygni		10	15	13	10	12	10
Nov. 3	17	Nov. 5	6	15	5	16	8	16	13
10	11	9	20	19	20	19	5	20	16
17	6	14	9	24	10	22	3	24	18
24	0	18	23	29	0	25	1	28	21
30	18	23	13			27	23		
		28	3			30	20		

Maxima of Variable Stars of Short Period not of the Algol Type.

Unless otherwise indicated the times of maxima only are given; and the times of minima may be found by subtracting the interval printed in parentheses under the names of the stars.

SY Cassiop.		SU Cassiop.		SX Aurigae		RZ Gemin.		δ Gemin.	
d	h	d	h	d	h	d	h	d	h
Nov. 3	12	Nov. 22	0	Nov. 14	21	(−1	7)	(−5	0)
7	14	23	22	16	10	Nov. 3	6	Nov. 1	10
11	11	25	21	17	23	8	18	11	14
15	17	27	20	19	11	14	7	21	18
19	19	29	19	21	0	19	19		
23	21	SV Persei		22	13	25	7	RU Camelop.	
27	22	Nov. 3	2	24	2	30	20	(−9	12)
RY Cassiop.		14	5	25	15	RS Orionis		Nov. 16	1
(−5	19)	25	8	27	3	(−2	0)	V Carinæ	
Nov. 15	12	RX Aurigæ		28	16	Nov. 5	20	(−2	4)
30	7	(−4	0)	30	5	13	10	Nov. 4	3
SU Cassiop.		Nov. 9	7	SY Aurigae		20	23	10	20
(−0	22)	20	22	Nov. 2	20	28	12	17	12
Nov. 2	12	SX Aurigae		12	23	T Monoc.		24	5
4	11	Nov. 1	2	23	2	(−9	23)	T Velorum	
6	9	2	15	Y Aurigae		Nov. 17	1	(−1	10)
8	8	4	4	(−0	18)	W Gemin.		Nov. 5	12
10	7	5	17	Nov. 4	6	(−2	2)	10	4
12	6	7	6	8	2	Nov. 4	20	14	19
14	5	8	18	11	23	12	18	19	10
16	3	10	7	15	20	28	14	24	2
18	2	11	20	19	16			28	17
20	1	13	9	27	10				

Maxima of Variable Stars of Short Period not of the Algol Type.

Continued.

W Carinæ

d	h
(−1	0)
Nov. 7	20
12	5
16	14
20	23
25	8
29	16

S Muscæ

d	h
(−3	11)
Nov. 4	21
14	12
24	4

T Crucis

d	h
(−2	2)
Nov. 2	16
9	9
16	3
22	21
29	14

R Crucis

d	h
(−1	10)
Nov. 2	15
8	10
14	6
20	2
25	22

S Crucis

d	h
(−1	12)
Nov. 5	7
10	0
14	17
19	9
24	2
28	18

RZ Centauri

d	h
Nov. 1	6
2	4
3	3
4	1
5	0
5	22
6	21
7	19
8	18
9	16
10	15
11	13
12	12
13	10
14	9
15	7
16	6
17	4
18	3
19	1
20	0
20	22
21	21

RZ Centauri

d	h
Nov. 22	19
23	18
24	16
25	15
26	13
27	12
28	10
29	9
30	7

W Virginis

d	h
(−8	5)
Nov. 16	15

V Centauri

d	h
(−1	11)
Nov. 2	18
8	6
13	18
19	6
24	18
30	5

R Triang. Austr.

d	h
(−1	0)
Nov. 2	2
5	12
8	21
12	6
15	16
19	1
22	10
25	20
29	5

S Triang. Austr.

d	h
Nov. 1	2
7	10
13	18
20	1
26	9

S Normæ

d	h
(−4	10)
Nov. 8	19
18	13
28	8

RV Scorpii

d	h
(−1	10)
Nov. 1	8
7	9
13	11
19	12
25	14

RV Ophiuchi Minimum

d	h
Nov. 3	8
7	0
10	17
14	9
18	2
21	18
25	11
29	3

X Sagittarii

d	h
(−2	22)
Nov. 5	5
12	6
19	6
26	6

Y Ophiuchi

d	h
(−6	5)
Nov. 2	8
19	11

W Sagittarii

d	h
(−3	0)
Nov. 3	22
11	12
19	3
26	17

Y Sagittarii

d	h
(−2	2)
Nov. 2	6
8	1
13	19
19	14
25	8

U Sagittarii

d	h
(−2	23)
Nov. 5	4
11	22
18	16
25	9

β Lyræ

d	h
(−3	7)
(−3	2)
Nov. 5	15
12	8
18	13
25	5

κ Pavonis

d	h
(−4	7)
Nov. 6	22
16	0
25	2

U Aquilæ

d	h
(−2	4)
Nov. 2	12
9	12
16	13
23	14
30	14

U Vulpec.

d	h
(−2	3)
Nov. 6	10
14	9
22	9
30	8

SU Cygni

d	h
(−1	7)
Nov. 3	10
7	6
11	2
14	23
18	19
22	15
26	12
30	8

η Aquilae

d	h
(−2	6)
Nov. 7	8
14	12
21	17
28	21

S Sagittae

d	h
(−3	10)
Nov. 4	2
12	11
20	20
29	5

X Vulpec.

d	h
(−2	1)
Nov. 6	4
12	11
18	19
25	3

V Vulpec. Minimum

d	h
Nov. 18	1

X Cygni

d	h
(−6	19)
Nov. 9	9
25	19

T Vulpec.

d	h
(−1	10)
Nov. 5	9
9	11
13	21
18	8
22	18
27	5

TX Cygni

d	h
Nov. 13	22
28	15

VY Cygni

d	h
(−2	14)
Nov. 8	14
16	11
24	8

VZ Cygni

d	h
(−1	1)
Nov. 1	22
6	19
11	16
16	12
21	9
26	6

Y Lacertae

d	h
(−1	10)
Nov. 4	22
9	6
13	14
17	22
22	5
26	13
30	21

δ Cephei

d	h
Nov. 2	14
7	23
13	8
18	17
24	1
29	10

Z Lacertae

d	h
Nov. 4	20
15	17
26	14

RR Lacertae

d	h
Nov. 4	2
10	13
16	23
23	9
29	19

V Lacertae

d	h
(−1	10)
Nov. 1	11
6	11
11	10
16	10
21	9
26	9

X Lacertae

d	h
Nov. 3	19
9	6
14	19
20	3
25	14
30	25

SW Cassiop.

d	h
Nov. 5	19
11	6
16	16
22	2
27	13

RS Cassiop.

d	h
(−1	19)
Nov. 6	12
12	19
19	2
25	10

RY Cassiop.

d	h
(−7	10)
Nov. 5	22
18	2
30	5

Two New Variables 36 and 37 1911.—In *A. N.* 4516 attention is called to two short period variables discovered at the Transvaal Observa tory. Their positions are

36.1911 Librae $\alpha = 14^h\ 20^m\ 26^s.5$ $\delta = -20°\ 57'.6$ (1875.0)
37.1911 Librae $14\ 51\ 42.8$ $-14\ 41.3$ (1855.0)

The first was discovered by R.T.A. Innes and on three photographic plates varies between magnitudes twelve and fourteen. The period is about five hours, the rise to maximum being steep and the descent slow.

The second was discovered by H.E. Wood and on five plates varies between 11 and 15 5 magnitude.

New Variable Stars 38-41 1911.—These are announced in *A.N.* 4519 by Mr. P. Guthnick of Berlin. They are all short period variables with small amplitude of variation. The ordinary amateur observer can probably do nothing with them. Their positions for 1900.0 are as follows:

	α			δ		B.D.Mag.
	h	m	s	°	′	
38.1911 Cassiopeiae	1	04	57	+ 63	40.3	6.0
39.1911 Comae	13	30	40	+ 23	19.0	7.5
40.1911 Herculis	18	50	14	+ 20	29.3	6.5
41.1911 Canum Ven.	13	03	38	+ 39	16.6	7.5

38.1911 Cassiopeiae is about 49′ south of 32 Cassiopeiae and is very similar to the latter in its variation. The amplitude of variation is about 0.3 magnitude and the period about one day.

39.1911 Comae varies between magnitudes 8.0 and 8.3 in a period of 31 days. The variation is of the δ-Cephei type, the interval from minimum to maximum being twelve days. A maximum occurred 1911 July 17.

40.1911 Herculis has a period of about 5.25 days, the range being between magnitudes 6.95 and 7.2. The light curve is very nearly symmetrical.

41.1911 Canum venaticorum is the brighter component of the double star Σ1723. The distance between the components is 6″.7. The range of variation is between magnitudes 8.0 and 8.3, in a short period, which is as yet not determined.

COMET NOTES.

A Swift-moving Cometary Object.—In *A.N.* 4517 Mr. J. Franz of Breslau states that on July 22, 1911, while searching for Kiess' comet he found a nebulous object which changed 3^m in right ascension within the interval of six minutes. The change in declination was not noticeable. The object appeared of about the sixth magnitude and 6′ in diameter. Its position at $13^h\ 4^m$ (middle European time) was $\alpha = 4^h\ 15^m.0$ $\delta = +20°\ 36'$. Other observers on succeeding nights were unable to find the object. Mr. Franz thinks the object was a comet very near to the earth and calculates, assuming parabolic velocity, that its distance was 2.7 $\sin\alpha$ times the moon's distance, α represent-ign the angle which the comet's direction of motion makes with the line of sight.

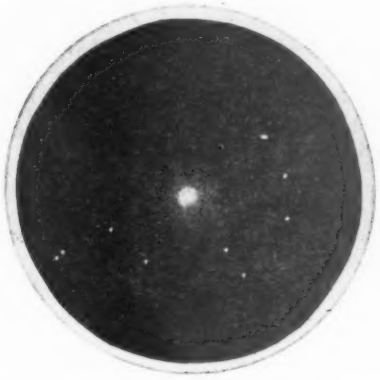
Definitive Orbit of Comet 1893 I (Brooks).—In *A. N.* 4513 Mr. Joseph Polak of Moscow, Russia, gives the results of a definitive determination of the elements of the orbit of the comet 1893 I discovered by Brooks at Geneva, N. Y., November 19, 1892. The computations give hyperbolic elements as the most probable but are not decisive so that the following parabolic elements may be taken as correct within the errors of observation.

$$\begin{aligned} T &= 1893 \text{ Jan. } 9.53212 \text{ Berlin m. t.} \\ \omega &= 85^\circ\ 13'\ 07''.82 \\ \Omega &= 185\ \ 39\ \ 07\ .67 \quad 1893.0 \\ i &= 143\ \ 51\ \ 47\ .27 \\ \log q &= 0.0774072 \end{aligned}$$

Comet *b* 1911 (Kiess):—On the morning of July 7, 1911, Mr. Kiess, from Lick Observatory, Mount Hamilton, California, discovered the second comet of this year. This discovery was made by means of photography.

As soon as I received from Harvard Observatory the cablegram relative to this comet I tried to find it, but bad weather prevented me from doing so.

It was not until the 20th that I could find the beautiful comet, using my "Zeiss" telescope with an eye-piece of power 48.



COMET KIESS OBSERVED AT $4^h\ 20^m$ ON THE MORNING OF TUESDAY 1911 JULY 25, BY PROF. LUIS G. LÉON.

The nucleus was very bright and the coma very luminous. The comet was in the neighborhood of "Iota" Aurigae. The aspect of the celestial wanderer was that of a cotton flake with a condensation in the center. It reminded me of Halley's comet in January 1910, but Keiss' comet is much brighter.

This morning (July 27) at four o'clock, I observed the comet and I could distinguish perfectly a star of about the eighth magnitude through the aster's coma. This demonstrates once more how light and transparent is the cometary matter.

The comet is no more in the constellation of Aurigae; it has passed to Taurus and it goes with great speed.

Professor Luis G. León.

México City, July 27, 1911.

Comet *b* 1911.—Kiess' comet *b* 1911 has moved very rapidly across the sky and is now visible only in southern latitudes. The diagram, constructed from Kobold's elements, shows that the comet was discovered soon after it came out from conjunction with the sun, having already passed perihelion and that it passed nearest to us about the middle of August. The orbit of the comet passes very close to the path of the earth at the descending node and,

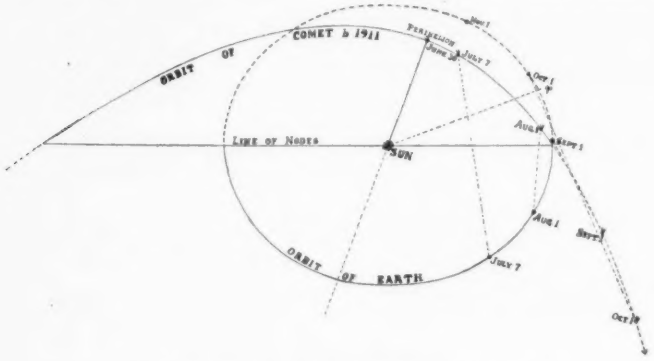


DIAGRAM OF THE ORBIT OF COMET *b* 1911 (KIESS).

had the comet come along about twenty-five days later, we should have been very close to it and might have seen a brilliant spectacle. In the diagram the dotted portion of the earth's orbit is beyond the plane of the comet's path and the dotted portion of the comet's orbit is below the plane of the earth's orbit. The projection is as if the earth's path were seen against the plane of the comet's orbit. The inclination of the two planes one to the other is 31° 33′.

Photographs of Comet *b* 1911:—I am sending you a couple of prints from our negatives of Comet *b*. A photograph taken about August 1, showed a very faint tail, thus eliminating all hope that the comet might become bright enough to be an interesting object, at least photographically.

C. C. KIESS.

Lick Observatory,
Mt. Hamilton, Cal. Aug. 14, 1911.

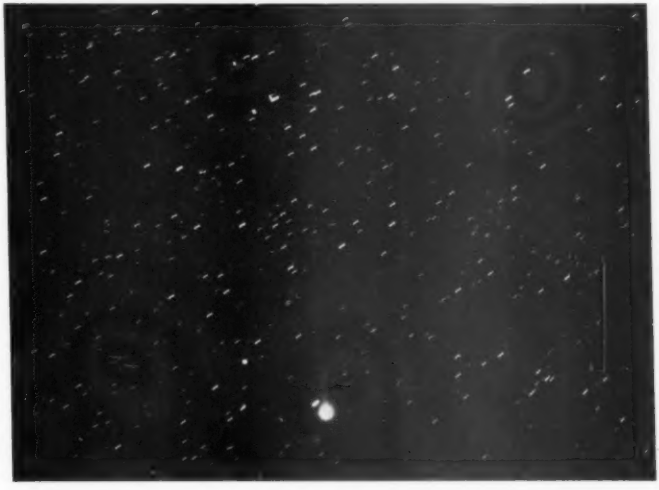
Elements and Ephemeris of Comet *b* 1911 Kiess:—The following elements and ephemerides computed by Messrs Einarsson and Meyer at the Berkeley Astronomical Department of the University of California were received just too late for the August-September number of POPULAR ASTRONOMY. The comet is already too far south for observation in our latitude.

The orbit is based on the following observations:

	1911 Gr. M.T.	α (app.) h m s	δ (app.) ° ′ ″	Observer
1)	July 7.9488	4 50 5.6	+ 35 7 41	Kiess (L.O.)
2)	July 11.9533	4 43 8.4	+ 34 29 24	" "
3)	July 15.9535	4 36 5.0	+ 33 29 29	" "

PLATE XV.

1911 July 8. Exposure 1 hour by R. S. Sheppard with Dallmeyer lens.
Mid-exposure $3^h\ 3^m$ a. m., P. S. T.



1911 July 24. Exposure 2 hours by C. C. Kiess with Willard lens.
Mid-exposure $2^h\ 30^m$ a. m., P. S. T.

PHOTOGRAPHS OF COMET *b* 1911 KIESS TAKEN AT THE LICK OBSERVATORY.

PRELIMINARY ELEMENTS.

T (Perihelion date) 1911 June 30.2827 Gr. M. T.
$\Omega = 158°\ 46'\ 29''$
$\omega = 111\ 11\ 9$ } Ecliptic 1911.0
$i = 148\ 30\ 42$
$q = 0.69858$

EPHEMERIS.

1911 Gr.M.T.	True α			True δ		
	h	m	s	°	′	″
July 26.5	4	14	50	+ 30	4	2
28.5	4	9	46	+ 29	0	12
July 30.5	4	4	2	+ 27	43	51
Aug. 1.5	3	57	26	+ 26	10	58
3.5	3	49	41	+ 24	15	41
5.5	3	40	21	+ 21	49	13
7.5	3	28	50	+ 18	38	16
9.5	3	14	50	+ 14	22	26
11.5	2	55	16	+ 8	31	4
13.5	2	29	55	+ 0	23	26

An observation taken by Kiess on July 18 gave the following residuals:

$\Delta\alpha$ (O—C) + 22″ $\Delta\delta$ (O—C) — 21″

After August 13.5, the comet passes very quickly to minus declination, by August 19.5 its declination is south 36°, but it is about this date when the comet makes the nearest approach to the earth, being at a distance of about 0.25 (hundredths) of an astronomical unit and theoretically its brightness is about twelve times that of the discovery date (that is on August 19.5).

Comet *c* 1911.—This comet as the diagram shows was caught almost as soon as it could be, on its way in to perihelion, and its course has been quite favorable for observation. The paths of earth and comet approach each

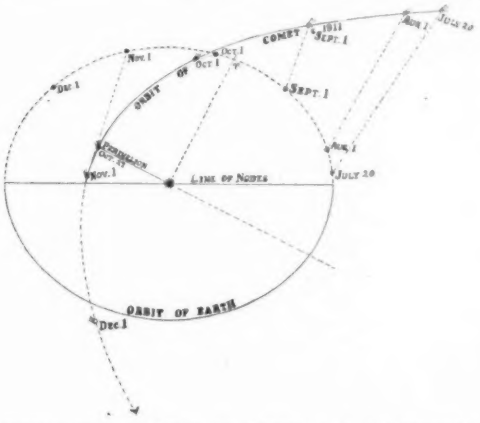


DIAGRAM OF THE ORBIT OF COMET *c* 1911 (BROOKS).

other until about October 1, after which the comet's rapid movement will carry it quickly away, but during the most of this month it will be approach-

ing the sun and hence getting intrinsically brighter all the time. It is now visible to the naked eye but has as yet no conspicuous tail. It is likely to be visible in the telescope through November and possibly December, but in the latter month will be seen only by southern observers. The diagram was constructed from elements by Mr. Young and Miss Aitken of the Lick Observatory.

Brooks' Comet, which is at present (September 6) moving northwest from the constellation Cygnus toward the constellation Draco and which is visible to the naked eye as an indistinct hazy patch of light in the sky, is being closely followed by Professor Barnard at the Yerkes Observatory. He has secured a number of splendid photographs which show considerable condensation and also a large extent of tail. From a photograph taken on September 2, Professor Barnard finds that the head of the comet is nearly 510,000 miles in diameter, and that the tail has an extent of about 8°, which is approximately equivalent to ten million miles. Because of its position in its orbit this vast extent of the tail is not apparent since it is inclined toward the earth and is therefore foreshortened by perspective. On this date the ephemeris of the comet shows it to be about 50 million miles away, or a little more than half as far as the sun.

Second Elements and Ephemeris of Comet *c* 1911 (Brooks.)

The following observations have been used for the determination of a second set of elements:

1911 Gr.M.T.	α (1911.0)	δ (1911.0)	Observer
July 21.74304	333 14 38.6	21 34 40 1	Aitken
Aug. 4.71330	328 44 58.8	30 11 54.4	Kiess
Aug. 18.70793	318 11 59.8	41 29 05.1	Kiess

The third of these is the mean of two observations. The dates and coördinates are corrected for planetary aberration and parallax respectively, on the basis of the geocentric distances corresponding to a previous orbit.

ELEMENTS.

$T =$ Oct. 27.6825 Gr.M.T.
$\omega = 152° 50' 29.''7$
$\Omega = 293\ 05\ 15.\ 3$ 1911.0.
$i = 33\ 56\ 6.\ 1$
$q = 0.3489506$

O—C	I	III
cos δ Δα	+ 4″	− 2″
Δδ	−14	+ 5

CONSTANTS FOR THE EQUATOR 1911.0.

$x = r\,[9.933523] \sin (180° 02' 07''.4 + v)$
$y = r\,[9.928072] \sin (\ 68\ 00\ 31\ .3 + v)$
$z = r\,[9.868476] \sin (123\ 08\ 02\ .4 + v)$

Although these parabolic elements admit of some improvement, the residual of −14″ in the first declination indicates, according to the method of solution, that the orbit is slightly elliptic. The parabolic elements, however, given above, will represent the motion of the comet with sufficient accuracy for some weeks to come. An observation taken by Mr. D.W. Morehouse at the Students Observatory on September 4 is represented as follows, O—C:

$$\cos\delta\Delta\alpha = +4'', \qquad \Delta\delta = -21''.$$

The computation of the elements has been checked in part by Messrs. E. L. Haynes and G. H. Pitman.

REYNOLD K. YOUNG.

From the foregoing parabolic elements by Mr. R. K. Young we have computed the following ephemeris:

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1911	True α	True δ	Log Δ	Br.
	h m s	° ′ ″		
Sept. 15.5	16 47 10.7	+56 39 12	9.7140	17.7
17.5	16 21 45.7	55 48 42		
19.5	15 57 36.8	54 39 28	9.7131	20.4
21.5	15 35 00.5	53 13 29		
23.5	15 14 04.6	51 32 58	9.7171	23.2
25.5	14 54 49.5	49 39 58		
27.5	14 37 11.5	47 36 22	9.7257	26.0
Sept. 29.5	14 21 04.6	45 23 46		
Oct. 1.5	14 06 21.6	43 03 26	9.7387	29.0
3.5	13 52 55.6	40 36 21		
5.5	13 40 40.4	38 03 16	9.7500	31.9
7.5	13 29 31.0	35 24 48		
9.5	13 19 23.4	32 41 17	9.7776	34.7
11.5	13 10 15.5	29 53 16		
13.5	13 02 06.1	27 01 06	9.8035	37.0
15.5	12 54 55.1	24 05 16		
17.5	12 48 43.2	21 06 25	9.8337	38.1
19.5	12 43 31.7	18 05 17		
21.5	12 39 21.9	15 02 49	9.8677	37.3
23.5	12 36 14.8	12 00 09		
25.5	12 34 10.5	8 58 35	9.9041	34.2
27.5	12 33 07.6	5 59 30		
Oct. 29.5	12 33 03.2	3 04 25	9.9413	29.0

ELI S. HAYNES,
JOHN H. PITMAN.

Berkeley Astronomical Department,
September 11, 1911.

Encke's Comet.—Encke's periodic comet was discovered first at its present return by Director F. Gonnessiat of the Algiers Observatory on July 31. It was seen under unfavorable circumstances, near the horizon, but appeared as a white spot, quite condensed, of about 30″ diameter. On August 1, while rising from the horizon, it became visible before stars of the ninth magnitude. Director Gonnessiat thinks that in the darkness of complete night it would have been estimated as from seventh to eighth magnitude.

Since its discovery the comet has passed perihelion and come out on the east side of the sun but not far enough to make it easy to observe. It will not come into a favorable position for observation at this return.

Comet 1905 II Re-discovered.—A cablegram from Kiel Observatory via Harvard College Observatory announces that Borrelly's periodic comet 1905 II was observed by Knoxham at Nolwan (probably Helwan, Egypt) September 19.5414 Greenwich mean time. Its position was then

$$\alpha = 3^h\ 46^m\ 20^s \qquad \delta = -32^\circ\ 54'$$

It is visible in a large telescope.

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

The Conjunction of Mars with Saturn on August 16 was watched for impatiently in this city, for the treat to see the two interesting objects at the same time in the field of a telescope does not occur so often and the unusually prolonged cloudy condition of the sky made the view of it somewhat doubtful. Our telescope is a Brashear Reflector of 8¼-inch aperture and 72-inch focal length.

The conditions for seeing on this evening were not ideal. The Milky Way could hardly be distinguished, the Andromeda nebula, while fairly bright in the center, did not afford a sight of the outlying ends of the wedge. Vega, near the zenith, showed best, the little companion being plainly seen.

Near midnight the telescope was pointed to the showpiece of the evening and with a 72 power the two planets were in the field. The contrast in color between the two objects was very striking, yes startling. The burnished coppery color of Mars made Saturn appear of a greenish tint, more so than ever noticed before. Was it caused by contrast? The definition of Saturn was much better than that of Mars. The shadow of the planet was very distinct on the ring, and the division in the ring came out plainly in steady moments, while in Mars the outline seemed to be seething and boiling, and nothing but the gibbosity of the planet could be made out.

With higher power this difference of defining was the same. The features in Saturn were steady, while in Mars no detail would come forth, owing to the poor definition. Now, both objects were being looked at through the same stratum of air, and should be affected alike, or is the explanation to be sought, in the relative nearness of Mars to the Sun, compared with Saturn and the reflection sent back to us from them both? Will some of your correspondents kindly shed some light on this and volunteer some information?

HERMAN FRITZ.

Chattanooga Museum Observatory,
August 25, 1911.

Venus Visible at Conjunction.—On September 12, Venus was in inferior conjunction, yet was plainly visible to the naked eye. This rather remarkable phenomenon was due to the unusual fact that Venus was ten degrees south of the sun, a distance safely out of the strong glare on a very clear day.

About half past two of the afternoon of the 12th, the writer judged as nearly as possible the position of Venus relative to the sun, about ten degrees south, and pointed a small portable telescope without tripod to that region of the sky. A tiny spot of light soon flashed across the field. When the object was recovered and the instrument was sufficiently steadied, the thin but clear silvery crescent with horns pointing downward was unmistakable. Laying the telescope aside, the observer with eyes shaded looked into the bright but unusually blue sky beside the sun and succeeded in seeing Venus distinctly with the unaided eye. Several subsequent glimpses within the next few minutes were quite as successful. Venus, although as near to the sun as it

could possibly be during this passage was clearly visible, thus having a doubly long interval of visibility in this synodic period, its visibility being uninterrupted at conjunction. In the southern hemisphere in latitudes equal to our own, Venus has been enjoying the distinction of being both "morning star" and "evening star" at the same time and undoubtedly could have been seen as such

The visibility of Venus in conjunction is quite an interesting phenomenon and will not often be observed because the planet usually passes in conjunction much closer to the sun. What made this possible at this passage is the fact that Venus was so far from the sun even at its closest point, which might seem remarkable when it is remembered that Venus' orbit is inclined only about three degrees to the plane of the ecliptic. But this is easily explained by its proximity to the earth during inferior conjunction.

This phenomenon is, in a sense, the opposite to that of a transit, which will not occur for nearly two hundred years. It is the writers opinion that Venus is always invisible to the naked eye at a superior conjunction.

HAROLD B. CURTIS.

New Castle, Pa. September 13, 1911.

Audibility of Aurora Borealis.—In the August POPULAR ASTRONOMY Mr. Charles Caverno mentions a case in which the Aurora Borealis made a "swishing" and "crackling" sound. This brings to mind one I witnessed in August 1893, and as I can do no better than to quote the record in my notebook, will do so in full, as I believe it has never been published before.

"1893 August 6, 8:45—1:00hr. One of the grandest auroras that it has been my privilege to witness. When first seen, it resembled dawn, only it was in the north. This continued a few minutes when rays of white light shot up two-thirds of the way to the zenith. This was followed by the usual flashing, waving, flickering light; this changed to a resemblance of clouds of smoke intermingled with flames of fire. This continued for some time rolling and tumbling, when it again changed to the flashing, rolling, waving, sheets of light, flashing past the zenith, being the most brilliant in the north-east. A little north of west, a narrow but bright band of light shot up and extended through the zenith, to the eastern horizon. While this was in progress a short spindle shaped, but intensely bright ray of light appeared above Polaris, parallel to the horizon. The thick part of this ray of light moved rapidly from east to west and back again in quick succession until it finally stopped and disappeared. Again the scene changes and resembles an immense conflagration. Columns of smoke intermingled with leaping flames and tongues of fire roll and tumble as if driven by a strong wind. With it there was a roaring as if caused by an immense fire at some distance. The air was perfectly still, so that it was not caused by the wind. The scene brought vividly to mind the words of the prophet in Joel 2:30." Observed at Randolph, Ohio.

While I have witnessed many aurorae before and since this one, yet it is the only one in which a sound that could only be attributable to it, was audible; yet, in nearly all the other cases the conditions under which they were observed, were such to mask any sound which the aurora might have made, as that due to trains, street cars, and other noises due to city activities. The conditions under which the one described above was observed, were ideal in every way, the night was perfectly still, and Randolph was five miles from

any railway, and ten miles from any city. The rising moon obliterated the display at one o'clock A.M., having been continuous for over four hours.

At 6hr. that afternoon an immense and very active group of spots was seen south of the center and a little east of the central meridian of the sun.

WM. E. SPERRA.

Cleveland, Ohio, 1911 Sept. 10.

February as an Anniversary month.—With reference to Dr. Campbell's note at p. 80 of Vol. XIX on February, one may add that Jannsen the French Astronomer was born at Paris on February 22, 1829. Nova Persei was discovered by Anderson and J. E. Gore in 1901 on the same date.

V. RAMESAM.

Vakil, High Court, Madras, India.

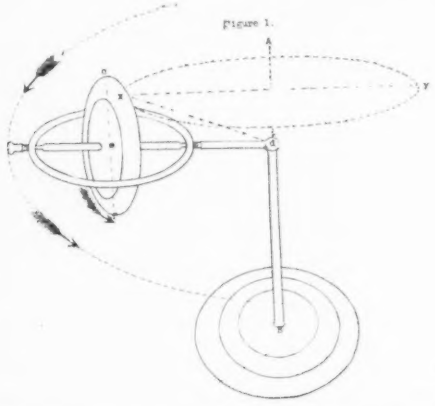
A Brilliant Meteor.—A very brilliant meteor was observed from this station on Saturday June 3 at 9:40 p.m. Its brightness almost rivalled that of the moon, which was at first quarter. It started from near the zenith and passed in a northeasterly direction, and within about 15° of the horizon it appeared to burst or break in pieces.

J. G. APPLE.

Sagertown, Pa., Lat. 41° 43′, Long. 80° 9′.

The Gyroscope—A Qualification. Your magazine for June-July is at hand; and on reading in cold type my last article on the Gyroscope as a Compass, in view of information that this class of instrument operates very slowly, I fear that I shall have to qualify for the present at least the main point, that it demonstrates gravity to be a pressure instead of an attraction. I had sup-

Figure 1.



posed from the statements of others that a free-moving gyrostat acted with considerable speed in bringing its axis into line with that of the earth. On the contrary it appears to act very slowly indeed moving simply as the mechanical effect of the earth's motion tending to pull the axes of all bodies rotating freely on its surface into line with its own axis.

However in this, which every tyro in mechanics will understand, it may be pointed out that the gyroscope as a compass affords indirect support that gravity is a pressure, in the analogy between this very influence of the earth and the action of the ordinary type of instrument.

As the effect of a rotating globe or disc with another globe or disc resting upon its surface, is to pull the axis of the latter into line with its own axis, or unify the movement in other words, so in the common gyroscope (figure 1), the mechanical tendency is to reduce the rotation of the disc which may be assumed to roll on $x - - y$ to a revolution around $x - - d$, in the effort to unify the two rotary movements with centers at e and d; which revolution would actually begin, if there were not a positive force above the center of gravity e, holding it to a steady, uniform movement.

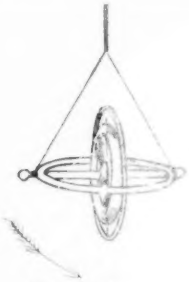


FIGURE 2.

FIGURE 3.

The unequal stress of the centrifugal forces of the sides of the disc—that nearest in figure 1, being thrown outwardly and the farthest inwardly by the natural descent—may be shewn by analysis; and this unequal stress would cause the instrument to collapse were it not for a steadying force in the median line $c—f$ of the disc, passing through the center of gravity supposedly at e.

That such a steadying force exists, is the result of and practically identical with the rotative force of the disc tending to preserve its plane of motion, is shown in the fact that a rotating disc suspended as shown in figure 2, will whirl around this central line by the slight twist even of the suspended string, but strenuously resists any attempt to tip it to the right or left across the plane of motion when supporting itself as shown in figure 3; and that the force exerted in this median line must come from above was pointed out in the previous articles.

HYLAND C. KIRK.

Washington, D. C. June 16, 1911.

Genesis and Science.—In the POPULAR ASTRONOMY for August-September, 1911, there is an article by Mr. Macpherson, in which he attempts to show that there is a wonderful harmony between the account of creation as given in Genesis, and the discoveries of Science.

Had the article appeared in a religious journal, it would have called for no reply, since we expect to see articles of that kind in this class of publication, but it is surprising to see such an article in a scientific magazine of the twentieth century.

Let us briefly examine a few verses of the first chapter of Genesis.

"In the beginning God created the heaven and the earth." This statement is unscientific for science knows no such conception as a universal beginning of things, including matter. The passage moreover, has been wrongly translated, since the Hebrew word, *Elohim*, here rendered God, is plural in form.

It is also, in the present case, plural in meaning as the context plainly shows: See chapter, 1 verse 26, and chapter 3, v 22.

The passage, therefore, should have been rendered as follows: "In the beginning the Gods created the heaven and the earth." This rendering harmonizes with another passage in the Bible, which says, "There are Lords many, and Gods many." The false rendering however, has been retained, since the necessity for upholding the monotheistic doctrine was felt to be so urgent, that Christian writers were only to willing to perpetuate the pious fraud.

"And the earth was without form and void."

Every scientist knows that nothing can exist without a form, whether it be in the solid, liquid, or gaseous state. As Professor Huxley has said the wildest and most fantastic streak of mares-tail cloud that ever floated in the sky has a form.

As for the statement that the earth was void, I would ask, void of what? The passage does not say, and therefore it has no meaning unless it means void of matter, which would be false and absurd.

Of course if the passage were understood in a poetic or metaphorical sense, it might pass; but Mr. Macpherson insists on the scientific value of the first chapter of Genesis; and it is only from a scientific point of view that we are regarding it.

"And darkness was upon the face of the deep."

Not so; for there could have been no darkness upon the earth at this time. The writer is here speaking of the earth as a distinct entity, after it has been separated from the sun. But, according to the nebular hypothesis, the earth at the time of its separation was glowing with heat and light, and not until the earth's crust had solidified, and ceased to become luminous, could it be said with any scientific truth, that "darkness was upon the face of the deep." Hence, in the development of the earth, light preceded darkness, and not darkness light, as Genesis affirms.

Professor Guyot, in a frantic attempt to save Genesis, interprets the second verse as referring, not to the Earth, but to the primitive nebula from which the earth was thrown; and he acknowledges that unless this view is adopted, a reconciliation of Genesis with science, will be very difficult, if not impossible. The view, I believe, has not generally been accepted by Bible defenders; although their consciences have usually been elastic enough for the utmost stretch of interpretation, when necessity required.

But even if we accept Guyot's interpretation, this will not help matters, as far as the question of darkness is concerned, for the primitive nebula (which is supposed to have been the result of a previous collision) existed as a fire-mist from the start, and was never involved in darkness.

"And the spirit of God moved upon the face of the waters." But why on the waters only, and why did it not permeate the mass, just as the force of gravitation does, which force is the most suggestive of the Divine energy of anything that we know? This is truly a superficial account of the creation.

A certain writer, who thinks he sees a profound truth in the above passage, calls attention to the fact that electricity tends to accumulate on the surface of bodies.

"And God said, Let there be light and there was light."

It is remarkable that the only branch of physics which the writer seems to have known, was light, although gravitation and heat played a much more important part in the development of worlds. His knowledge of light, however, was not sufficient to prevent him from falling into a fatal error, for according to the present way of interpreting the passage, the creation of light implies a former condition of darkness either in the earth, or in the primitive nebula.

We have shown on theoretical grounds, that no such supposition is admissible. The results of observation also lead to the same conclusion. It has been estimated that if the whole heavens were conceived to be divided into 40,000 equal square parts, each one of those parts would contain, on the average, not less than three nebulæ. These nebulæ scattered all over the heavens, are seen in all stages of formation, from the most primitive, to the most developed; and the fact that they are all visible at such vast distances, shows that in no state of their existence are they covered with darkness.

Darkness did not prevail over the earth, until the earth's crust by gradual cooling had ceased to become luminous, and this must have been the stage at which the Genesis account of creation begins, if any sense is to be made of it. While this view will not make harmony between Genesis and science, it will make a nearer approach to it than any other interpretation. The darkness was accompanied by a condensation of vapors; and then "darkness was upon the face of the deep."

The subsequent penetration of the sun's rays through the vapors that remained, caused the first vicissitudes of light and darkness, and the beginning of the day of twenty-four hours. The Hebrew word *yom*, translated day, means a day of twenty-four hours, and good Hebrew scholars say that it never has any other meaning, except when it refers to that part of the day of twenty-four hours which is light. However that may be, it is evident that this is the meaning in the present case, for it is defined in such a way as to leave no doubt.

"The darkness he called night, and the light day."

But it seems hardly worth while to continue this criticism. Let the impartial reader study the other verses of the chapter for himself, and he will find that scarcely one of them has any more scientific meaning than those already examined.

The French writer Guibert, a firm believer in the Bible, comments as follows on the first chapter of Genesis: "In the present case a scientific revelation does not appear to have been made. In fact there seems to be nothing to lead the learned to any discovery. It is only by a forced application of the text, that an allusion can be found to the modern discoveries of science."

This sensible conclusion of Guibert, will undoubtedly be the ultimate verdict of every candid mind.

FRANK GILMAN.

Boston, Mass.

Question.—All other things being equal which diminishes the light in a telescope more—lengthening the focus of the objectglass or shortening the focus of the eyepiece? In other words which would give the best illumination, of two objectglasses having the same aperture, the one with the long focus and short ocular or the one with the short focus and long ocular—admitting the magnification to work out the same?

ANSWER.—The writer of the question has interchanged the words "long" and "short" as applied to the ocular in the two parts of the question. The magnifying power of any combination of objective and eyepiece is equal to the focal length of the objective divided by the focal length of the eyepiece. So the long focus objective would require the long focus eyepiece, and the short focus objective the short focus eyepiece, in order to give the same magnifying power. This being true the greater loss of light, the aperture of the objectives being the same, would be with the short focus combination, since the curvature of the lens surfaces must be greater and consequently more light would be lost by reflection at the several surfaces.

Question.—At what points of the compass does the sun rise on June 1, July 1, August 1 and September 1?

ANSWER.— On June 1.... .....31°N. of E.
July 1.....34°N. of E.
August 1.....25°N. of E.
September.....12°N. of S.

These figures were read off from a celestial globe adjusted to latitude north 45°, and are to the nearest degree. For other latitudes the figures would be different.

Question.—Do variable stars increase in brightness when at greatest distance from their companion or sun?

ANSWER.—A variable star is a sun (or two suns) of itself. Those with which we are most familiar are supposed to be pairs of suns, one brighter than the other, revolving around each other, their centers moving in a plane which passes close to the earth. When the darker one passes between us and the brighter one, part of the light of the brighter star is cut off. Sometimes the two stars are of equal brightness and so when they are not in line with each other we receive double the light that we do when one is in front of the other In neither case is the light of either star appreciably increased by reflecting the light of the other. There are many variables which cannot be explained in this way and for which we must imagine some cause which effects an actual change in the brightness of the surface of the star or stars.

NOTES FOR OBSERVERS.

Co-operation in Observing Variable Stars.—The suggestions which I made in the August number seem to be meeting with a favorable reception. Several have written expressing the wish that an amateur society be formed and it seems that a beginning can be made by forming a Variable Star Section. Mr. W. F. Olcott, 62 Church St., Norwich, Conn., who is now one of the observers coöperating with Harvard College Observatory in variable star work, has kindly offered to take charge of the necessary correspondence in the direction of such a section. I would suggest that all those who care to enroll themselves for systematic variable star work write at once to Mr. Olcott.

At present quite a number of observers are coöperating according to a plan suggested by Professor E. C. Pickering, Director of Harvard College Observatory, and these would form the nucleus of a strong variable star section.

It would not be my thought to interfere at all with this plan but simply to get more workers to coöperate in it and have them banded together as a part of an association. Professor Pickering in a private letter says: "I shall be glad to do anything I can to secure a greater amount of useful work from amateurs I think Mr. Olcott would be a very good man to have oversight of the work. The work as now conducted consists in the observers sending to this observatory on blank sheets, like that enclosed, the observations which they make. We then put them in shape, plot the curves and send them to you. We also are distributing without charge many photographs of regions of variables to those likely to make good use of them. At the end of each five years we are planning to publish them in detail. (See *Harvard Annals* 37 and 57). The results for 1906-10 are now in type, forming H.A. 63 Part I, and will probably be issued this autumn. The original observations are sent to Mr. Campbell, at Arequipa, for a discussion like that given in H. A. 57, Part I. All of these things cost money and require the permanent organization which a great observatory can best furnish, and which cannot be safely trusted to an amateur. It does not seem wise to interfere with this plan but there is a large amount of useful work which might be done in correspondence with the members, providing for neglected stars, distributing photographs, etc. I believe there is useful work for amateurs, instead of merely looking at the moon and planets."

In the Harvard Circular No. 166 Professor Pickering gives a list of 372 variables of long period which, in general, have a range of at least three magnitudes and are of magnitude 9.0 or brighter at maximun. Of these 257 are north of declination $-20°$. This list will doubtless be furnished to any qualified observer who will agree to undertake regular work, together with record blanks and photographic charts of the regions about the variables which shall be assigned to the observer.

Methods of Observing Variables.—The method recommended in Circular 112 to observers coöperating with Harvard is very simple. "A sequence of comparison stars is selected for each variable and the photometric magnitude determined as described in *Annals* 37. This magnitude, to the nearest tenth, is entered on the photographic charts. It is well to omit the decimal point to avoid mistaking it for a star. With a chart thus marked the observation consists in estimating the magnitude directly by comparing the variable with a brighter and fainter star. Thus if found to be distinctly fainter than a star marked 96, or of magnitude 9.6, and brighter than one marked 100, we enter the magnitude of the variable, 9.8; if nearly as bright as the brighter star, 9.7, and if equal to it, 9.6. These estimates are seldom found to differ by more than a tenth of a magnitude from those obtained by Argelander's method. No further reduction of these observations is required, and the light curve may be constructed next day, using times and magnitudes as coördinates. The observer should never look at the light curve before making the observations, as, if he knows what magnitude is to be expected, his observations will have little value."

For illustrations of the method I may refer the reader to the article on "Variable Star Work for the Amateur with a small telescope" by Mr. Olcott in the March 1911 number of POPULAR ASTRONOMY.

When the magnitudes of the comparison stars have not been determined accurately it is better to use Argelander's method, which consists in writing

down a sequence placing the variable between a brighter and fainter star, with numbers indicating the relative difference of brightness. Thus

a 5 *v* 5 *b*

would signify that the observer thought he could divide the difference in brightness between the comparison stars into ten gradations or steps and that the variable was just as near one as the other in the scale of brightness. If the comparison stars are more nearly equal the record may be

a 2 *v* 3 *b* or *c* 1 *v* 2 *d*.

When an observer has had sufficient practice, so that his unit of gradation or *step* becomes practically constant he may make a series of shorter sequences as:

a 5 *v*; *b* 3 *v*; *v* 2 *c*; *v* 7 *d*; etc.

Then whenever the magnitudes of comparison stars become known, the brightness of the variable can be determined from each of them separately.

What an Amateur can do.—Professor Phillip Fox, Director of the Dearborn Observatory protests against my cutting out the observation of sunspots from the list of valuable work that an amateur can do, and insists that observations with a small spectroscope of the regions in the vicinity of sunspots may be extremely interesting and valuable. I am glad to add this form of solar observation to the list.

Mr. Frederick C. Leonard suggests also the observation of the colors of the components of double stars. For this, however, observations with a refracting telescope are of little value. One should use a reflector with very perfect definition.

GENERAL NOTES.

Owing to an extraordinary sale, No's 156, June-July 1908; 161, January 1909; 169, November 1909; 170, December 1909, are out of our files. Requests for these numbers have not been numerous enough to warrant the reprinting of any of the issues, but still a number of our subscribers need them to complete their files of POPULAR ASTRONOMY. If any of our readers, therefore, have made all the use they care to of these numbers, and care to dispose of them, we should be very glad to buy them back at the rate of 30 cents a copy.

Dr. Robert H. Baker has been appointed director of the Laws Observatory of the University of Missouri.

Mr. G. Fayet of the Paris Observatory has been appointed astronomer at the Observatory of Nice, to succeed Mr. M. Simonin. (*A.N.* 4519).

New Observatory in Africa.—The Geographical Society of France has entrusted to Mr. R. Jarry Desloges the mission of erecting an observatory, more or less temporary, on the high plateaus of North Africa. Experimental observations have been made at various points in this vast region at an altitude of over 1100 meters and a site has been found which appears to combine all the required conditions. The observatory is in course of construction. (*A. N.* 4519).

Mr. Frank Watson Dyson F. R. S., Astronomer Royal of England received the degree of L.L.D. from the University of Edinburgh on July 7.

Meteors in July.—Mr. Denning writes from Bristol under date July 27:—"The present month has proved to be a record here so far as the number of meteoric observations is concerned, for watches were maintained on twenty-six of the twenty-seven nights. The seventeenth alone was overcast. Between the sixteenth and twenty-seventh I saw a considerable number of Perseid-like meteors, but they were directed from a radiant at 23° + 42° in Andromeda. There have been few genuine Perseids up to the date of writing." (*The Observatory*, August 1911.)

Standard Time Adopted throughout Portuguese Territories.—I beg to inform you that Standard Time will be in use, from 1912 January 1, throughout Portuguese territories, as follows:

8^h	0^m	E.	Macao, Portuguese Timor,
5	0	E.	Portuguese India (provisionally 5^h 30^m E.)
2	0	E.	Portuguese East Africa.
1	0	E.	Portuguese West Africa.
0	0		(Greenwich, or West Europe).—Portugal, St Thomé and Principe Islands, Whydah.
1	0	W.	Madeira, Portuguese Guinea.
2	0	W.	Açores and Cape Verde Islands.

This Observatory remains entrusted with the determination and the telegraphic transmission of Standard Time to the whole country, to the Lisbon Time-ball, and to the Time Station at the Meteorological Observatory, Ponta Delgada (St. Miguel, Açores).

I profit by this opportunity to state also that the most reliable geographical latitude of this Observatory is

Lat. N. 38° 42′ 30″.5 (Prime Vertical, Meridian, and Zenith Telescope series of observations from 1872 to the present printed or unprinted).

and that the name "*Lisbon, Tapada*" is now the most suitable for it, like for instance, "Florence, Arcetri", or "Naples, Capodimonte".

There has been built and is working since two years a new astronomical observatory at Lourenço Marques, whose geographical coördinates are (transit pier):

Lat. S. 25° 58′ 4.″9 ± 0.″2 (Meridian observations by Capt. Gago Coutinho).

Long. E. 32° 35′ 39.″4 ± 0.″05 (Moon culminations, simultaneously here, and geodetic connection with the Cape).

Altitude (top of pier) 59 metres.

Campos Rodrigues.
Vice Admiral P. N. Director.

Lisbon, Tapada. 1911, July 25.

The Meteor of July 16, 1911.—The bright meteor which passed near Chicago about 8 P.M., Sunday, July 16, 1911, was seen by myself and Professor H. L. Rietz of the department of mathematics, University of Illinois. We were in a rowboat on Hamlin Lake near Ludington, Michigan, and my estim-

ates of direction were necessarily rough. The altitude at the beginning was 13°, at the end, 10°, and the corresponding azimuths were 50° and 70° south of Venus. The apparent motion was slow, the estimated duration being five seconds for the flight of about 20°. The meteor was white and about ten times as bright as Venus. It left only a short trail, never more than two or three degrees, and there was no persistent luminous streak visible in the twilight after the disappearance of the main body. Although at times several small pieces were detached, there was no general bursting of the meteor.

As Hamlin Lake is about 175 miles from Chicago, my estimate places the minimum height at thirty miles, which is quite different from the estimates of some of the Chicago citizens who, according to newspaper report, thought that the body was a few hundred feet above the earth.

JOEL STEBBINS.

Hamlin Lake, Ludington, Michigan.
July 19, 1911.

The Solar Apex from a 5° Zone.—In *A. N.* 4499 Mr. Alexander Wilkens of Kiel, Germany, gives the results of a determination of the solar apex, by means of the proper motions of 620 stars, with relatively large proper motion, in the zone between declination +29°50 and +35°10. The proper motions were derived from a comparison of Wilkens' observations, made at the Küffner Observatory in 1905-06, with the Leiden A. G. Catalogue for 1875, and Bessels observations 45 years earlier. Of the stars used 233 were brighter than magnitude 8.5, but mostly about 7.5, 282 were between 8.5, and 9.0 and 105 were fainter than magnitude 9 0. The determination of the solor apex is thus dependent principally upon the motions of fainter stars than have hitherto been employed for this purpose. In spite of the fact that only a narrow zone of the sky was concerned, the result comes out in fair agreement with other recent determinations, the position of the apex being

R.A. = 286° Decl. = + 37°.

Hourly Number of Meteors.—In *A.N.* 4515 Mr. W. F. Denning gives a table exhibiting the hourly frequency of meteors. He says "The numbers are deduced from data obtained at Bristol (England) and relate to the mean of a.m. and p.m. observations and are for one observer watching a clear, moonless sky uninterruptedly. The results on which the table is founded were gathered during the years 1866 to 1911. There being no leap-year in 1900 and the great majority of the observations being taken before that year the dates may be regarded as one too early. Thus the Perseids at the present epoch will supply about 69 per hour on August 11, not on August 10 as formerly, for the maximum of that display is now on August 11 or 12.

"In various years the number of meteors appears to vary not only on individual nights but generally during a whole year. I saw many more meteors in 1877 than in 1887, but it is true my place of observation was better in the former year.

"My materials, though pretty abundant, are not sufficiently full for an exhaustive investigation and perfectly reliable results. However I believe the table will furnish a useful guide and be found approximately correct. It must be remembered that no two observers will obtain accordant observations. *Zezioli* in the beautiful skies of Italy and *Tupman* in the Mediterranean saw a surprisingly large number of meteors, while *Schmidt* at Athens and others appear to have recorded comparatively few, so that hourly rates computed

from the experiences of different observers must necessarily vary considerably. The values here given are fairly correct for my eye and for the circumstances under which I pursued the observations.

"I have taken no account of the great meteoric showers which I witnessed on 1866 November 13, 1872 November 27 and 1885 November 27, as the thousands of meteors appearing in such very exceptional displays would swell the numbers far beyond ordinary experience. The idea in forming the table was to show the hourly number of meteors to be expected on ordinary nights of the year when the conditions are favorable for viewing these phenomenon. In or near large towns where artificial illumination affects the sky, the frequency of meteors is not nearly so well marked as in country districts where darker skies enable much smaller objects to be observed.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	18	8	7	7	7	6	8	20	15	13	12	9
2	28	7	6	8	6	5	7	19	14	14	12	9
3	12	7	7	8	6	6	8	19	13	14	13	10
4	9	6	8	7	7	6	9	21	12	14	14	11
5	10	6	7	7	6	7	9	22	12	12	12	12
6	9	6	6	8	5	6	8	24	14	13	13	13
7	8	7	7	6	5	6	8	27	13	12	13	12
8	7	7	7	7	6	6	9	34	12	14	14	14
9	7	7	7	7	6	7	9	48	12	13	14	16
10	7	6	8	8	6	6	10	69	13	14	15	22
11	8	6	8	8	6	6	10	48	12	14	16	23
12	8	7	7	7	6	7	11	30	13	15	17	19
13	8	7	8	7	7	6	11	22	14	16	20	16
14	9	7	9	8	6	6	12	20	15	17	21	13
15	8	8	8	7	6	7	12	18	15	21	18	10
16	9	8	9	6	5	7	13	17	15	20	17	10
17	9	8	10	6	5	8	13	16	14	21	16	9
18	9	8	9	7	5	7	14	15	13	21	15	8
19	9	9	8	8	6	6	15	15	14	20	14	9
20	10	9	8	9	6	8	16	16	15	19	15	8
21	9	9	7	10	6	8	17	17	17	18	16	10
22	8	8	7	8	7	7	18	19	16	17	15	10
23	7	8	8	7	7	7	19	19	15	16	16	8
24	6	8	8	6	6	7	20	20	14	16	14	8
25	6	8	8	6	6	6	21	21	13	15	15	9
26	7	7	7	5	6	7	23	20	14	14	14	8
27	7	7	7	6	5	7	25	13	15	15	15	9
28	8	7	8	5	6	6	27	20	13	16	14	9
29	7		8	6	6	6	26	19	14	15	13	10
30	8		9	7	7	7	23	18	15	14	12	9
31	7		8		8		21	16		14		10

Peculiar Star Spectra Suggestive of Selective Absorption of Light in Space.—In *A. N.* 4513 Mr. V. M. Slipher calls attention to the spectra of a number of stars of the Orion type in which the calcium line K is sharp and stationary, while the other lines of the spectra are diffuse and show periodic displacements due to probable motion of the stars. Using *Campbell's* elements of the solar motion, he finds the calcium velocities as deduced from the ten stars β, δ and σ Scorpii, ζ Ophiuchi o, ξ and ϵ Persei and η, δ and ι Orionis, to be generally under four kilometers. It thus seems that the source of the calcium absorption has at most a very slow velocity in space and is therefore outside the solar system. All these stars are located in or near branches of the Milky Way.

"At present is is not possible to decide whether the phenomenon is due to extensive veils covering large regions of sky, like the affected regions of Scorpio, or whether the individual stars in the region each possesses, perhaps more optically than physically, a nebulous veil whose chief absorption is, so far as known, calcium."

PROFESSOR H. POINCARÉ the eminent French mathematician, has notified Professor T. J. J. See, Director of the Naval Observatory, Mare Island, California, that he made use of RESEARCHES ON THE EVOLUTION OF THE STELLAR SYSTEMS, Vol. II., in his course this year at the Sorbonne, insisting especially on the capture of planets as satellites under the action of a resisting medium. The course of lectures is being published, and is to appear in November.

The Gyro-Compass. In the May number of the *Observatory*, Mr. H. P. Hollis gives a description of the Anschütz Gyro-Compass, the workings of which had been demonstrated by Mr C. K. B. Elphinstone before the April meeting of the Royal Astronomical Society. In view of Mr. Kirks article in the June number of POPULAR ASTRONOMY, some parts of this note may be of interest to our readers.

"When Dr. Anschütz, whose name is associated with the gyro-compass now before the world, began experiments in the year 1900 he tried to realize Foucault's gyrostat with three degrees of freedom; but this had to be abandoned owing to the impossibility of making an instrument in which the center of gravity and center of suspension were absolutely coincident, and with the axes of rotation meeting exactly in this point. In 1906 he began to develop the simpler instrument in which there are only two degrees of freedom, and the present compass consists of a gyro-wheel having the essential parts of a small electric motor rigidly fixed in its interior, which causes it to rotate at 20,000 revolutions per minute. This gyro is carried upon a float free to move in a bowl of mercury so designed that as long as the gyro is not rotating the whole moving system is free to swing in every direction like a pendulum. The center of gravity of this whole moving system is below the meta center, so that when the gyroscope is set rotating the rotation of the earth tends in general to make the axis not horizontal, but the force of gravity and the upward pressure of the mercury form a restoring couple, which combined with the rotary force of the earth directs the axis of the gyro-wheel to lie north and south. It was seen early in the experiments that a great difficulty to be contended with was due to the fact that all the movements of the ship affect the gyro-wheel, and that oscillations once having been set up, it would be a long time before the instrument came to rest, which would have rendered it practically useless as a substitute for the magnetic compass; but this difficulty has been overcome by an ingenious device for damping the oscillations by means of small air-blasts through holes in the outer case of the gyro-wheel, which is one of the essential points of the invention.

"It appears from Mr. Elphinstone's remarks at the meetings that the original object of the designers of this compass was to make an instrument for us in polar expeditions, but that for this purpose the gyro-compass as at present constructed is quite unsuitable. Nevertheless, for general navigation from latitude 70° N. to 70° S., and especially for use on submarines and vessels where electric power is abundant, the new instrument is quite suitable, so that it is being adopted in the ships of the British, the German, and other

Continental navies. The Anschütz compass with its compass card is somewhat larger than the ordinary magnetic compass, and though it may be placed in a binnacle on deck in the ordinary fashion, it has the advantage that it may be placed below the water line, and its movement geared up and transmitted, so that the readings of its compass card may be exhibited in a magnified form in any part of the ship."

Radial Velocities of 150 Stars.—In the *Publications of the Lick Observatory* Vol IX, Part IV are given the detailed results of the observations made by the D. O. Mills Expedition to the southern hemisphere during the years 1903-06. The expedition during these years was under the charge of astronomer W.H. Wright of the Lick Observatory, assisted by Dr. H.K. Palmer. The volume contains the results of measures of spectrograms of 150 stars south of declination —20°. For most of these stars four or more spectrograms were obtained and the resulting radial velocities are given for all the measurable lines on each plate. In some cases as many as sixty or more lines were measured. The velocities from the individual lines are in most cases remarkably accordant, thus attesting the excellence of the plates as well as the accuracy of the measures.

Among the 150 stars forty-one have been found to have variable velocities and are therefore to be regarded as spectroscopic binaries. This is a remarkably large proportion of stars to be found binary and bears out the statement which has often come from the Lick observers that probably one third of all the bright stars are spectroscopic binaries.

As an addendum to the volume are given the orbits of three spectroscopic binaries, *a Carinae*, *α Pavonis* and *κ Velorum*, calculated by Dr. H. D. Curtis while he was in charge of the D. O. Mills expedition.

The Ottawa Meeting of the Astronomical and Astrophysical Society of America was held according to the program given in the August-September number of POPULAR ASTRONOMY, August 23-25, at the Dominion Observatory Ottawa, Canada. Almost all of the members put up at the Russell House, the official headquarters of the Society while at Ottawa. The meeting opened at the Observatory on Wednesday morning with President Pickering in the chair. Dr. King, Director of the Ottawa Observatory, welcomed the Society to Ottawa and read a communication of welcome from the Canadian Minister of the interior. The program as printed was carried out without change.

Two reports of standing committees were read. The first of these was by Dr. Campbell and was an informal report of the work of the Committee on Radial Velocities, appointed at the 1910 meeting. On the morning of Friday, August 25, Dr. Schlesinger, Chairman of the Committee on photographic Astrometry, read the first report of this Committee. This was followed by a symposium, at which Dr. Schlesinger presided, on the subject of the determination of absolute star places by photography. The symposium was opened with the papers of Professor Russell and Professor Pickering, whose titles are given below and was followed by a general discussion in which Professors Littell, Doolittle, Tucker, Pickering and Russell took part.

The officers elected for the ensuing year are: President, E. C. Pickering, First Vice-President, E. B. Frost, Second Vice-President, W. W. Campbell, Secretary, W. J. Hussey, Treasurer, C. L. Doolittle, Councillors, J. S. Plaskett and W. S. Eichelberger.

The Council decided to hold the next annual meeting at Allegheny Observatory, in August 1912. The Society will also meet at Washington in December, in connection with the meeting of the American Association for the Advancement of Science.

Among those present were Miss Cannon, Miss Furness, Miss Palmer, Miss Schwartz, Miss Whittin, Messrs. Apple, Bailey, Cannon, Chant, Curtiss, DeLury, Doolittle; Douglass, Eichelberger, Frisby, Harper, Jordan, King, Littell, Manson, Marsh, McDiarmid, S. A. Mitchell, Motherwell, Parker, Peters, E. C. Pickering, Plaskett, Russell, Schlesinger, Slocum, Stebbins, Stewart, Tatlock, Tucker and Turner.

The following is the list of papers which were presented:

1. E. C. PICKERING. A Method of Determining by Photography the First Point of Aries.
2. Miss ANNIE J. CANNON. The Spectra of 762 Double Stars.
3. Miss ANNIE J. CANNON. Classification of some Stellar Spectra Photographed with the Slit Spectroscope at the Allegheny, Lick and Yerkes Observatories, compared with those taken at Harvard with the Objective Prism.
4. J. A. PARKHURST. The Spectra and Colors of Red Stars of H. C. O. Classes N and R. (Lantern.)
5. W. E. HARPER. The Orbits of the Spectroscopic Components of *d* Bootis. (Lantern.)
6. JOEL STEBBINS. Studies of Bright Variable Stars. (Lantern.)
7. E. S. KING. The Variability of Polaris.
8. HENRY NORRIS RUSSELL. A Study of Visual Binary Stars.
9. FRANK B. LITTELL. The 6-inch Transit Circle of the United States Naval Observatory.
10. FRANK B. LITTELL. The Alt-Azimuth Instrument of the United States Naval Observatory.
11. W. J. HUMPHREYS. The Earth's Radiation Zones. (Lantern.)
12. W. J. HUMPHREYS. The Amount and Vertical Distribution of Water Vapor on Clear Days. (Lantern.)
13. Miss SARAH F. WHITING. Daytime Laboratory Work in Astronomy.
14. FRANK W. VERY. On Scales of Intensity for the Lines of the Solar Spectrum.
15. Miss HENRIETTA S. LEAVITT. Periods of Variable Stars in the Magellanic Cloud.
16. S. A. MITCHELL. The Radial Velocity of 96 Herculis.
17. R. H. TUCKER. The San Luis Observatory of the Carnegie Institution
18. C. C. SMITH. Short Formula for the Computation of Circum-meridian Azimuths.
19. R. M. STEWART. Changes in Collimation and Level of the Ottawa Meridian Circle.
20. J. S. PLASKETT. Preliminary Measures of the Solar Rotation.

A Fellowship in Astronomy.—There is a vacant fellowship in astronomy and mathematics at Goodsell Observatory. The candidate should be a college graduate, with a good preparation in elementary astronomy and college mathematics, including calculus. The stipend is enough to pay for room, board and college fees.